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Effectiveness and factors influencing the use of Root BP plus for pulpotomy in the treatment of caries-derived irreducible pulpitis in mature permanent teeth

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Abstract: *To investigate the effectiveness and factors affecting the use of iRoot BP plus for pulpotomy in the treatment of caries-induced irreducible pulpitis in mature permanent teeth. Sixty patients with caries-origin irreducible pulpitis in mature permanent teeth admitted to our hospital from March 2022 to November 2024 were selected for the study, and were randomly divided into the control group and the experimental group. The patients in the control group were given MTA antibacterial paste for pulp capping. Patients in the study group were given iRoot BP Plus root canal filling and restorative material to cap the pulp. Comparing the treatment success rates of patients in the two groups at 3, 6 and 12 months after surgery, the differences were not statistically significant (all P>0.05); comparing the degree of root resorption of patients in the two groups at 12 months after surgery, the differences were not statistically significant (P>0.05); The distribution of cases by variable/category and bivariate analysis showed that the size of perforation and apical foramen closure had a significant effect on the results (P<0.05), while the gender and age of the patients did not have a significant effect on the results (P>0.05). iRoot BP Plus can be used as a pulp capping agent in the treatment of caries-derived irreducible pulpitis in mature permanent teeth by pulpotomy, and there is no difference between iRoot BP Plus and MTA in clinical application. The factors influencing the use of iRoot BP plus for pulpotomy in the treatment of caries-induced irreducible pulpitis in mature permanent teeth are the size of the perforation and the closure of the apical foramen.*

Keywords: *iRoot BP plus; pulpotomy; caries-derived irreducible pulpitis in mature permanent teeth*

1. Introduction

The dental pulp is a fibrous loose connective tissue located in the hard tissues of the dentin, which is rich in blood vessels, lymphatic vessels and nerves. Retaining healthy pulp tissue and maintaining the vitality of the pulp is important for promoting the restorative regeneration of dentin and preserving the normal physiological function of the teeth[1]. Caries, trauma and other injuries can cause pulp damage to occur pulp inflammation. When inflammation occurs in the pulp, the blood vessels in the tissue dilate and permeability increases, and bleeding is often evident when the infected pulp is removed during treatment. The appearance of the pulp tissue, the amount of bleeding, the colour of the blood and the time it takes to stop bleeding are closely related to the degree of inflammation. Inflammation of the pulp is usually classified as either reducible or irreducible pulpitis. Reproducible pulpitis usually manifests as mild transient pain in response to cold or sweet stimuli; irreducible pulpitis usually manifests as dull, throbbing, severe or radiating pain, with an exacerbated and persistent response to temperature testing or the electric pulp test (EPT)[2]. Root canal therapy is a common treatment for irreducible pulpitis[3]; however, it is expensive, with many follow-up visits and high technical sensitivity. It requires standardised training, repetitive practice and a high level of clinical skills to perform complex root canal treatment in posterior teeth. As many patients forgo treatment and opt for extraction due to poor economic conditions and high treatment costs, there is a need to find an alternative, more cost-effective treatment modality. As early as 1929, Hess[4] reported a pulpotomy using calcium hydroxide. Pulpotomy refers to the use of biologically active materials to cover the pulpal section after removal of locally infected pulp under aseptic conditions to promote healing of pulpal injury and restorative dentin formation, thus preserving the viability of the remaining pulpal tissue, which includes both partial pulpotomy and crown pulpotomy[5]. iRoot BP Plus is a bioceramic material, mainly composed of calcium silicate, zirconium oxide, tantalum oxide, etc. It is weakly fluid and paste-like, with the characteristics of easy to shape and

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rinse-resistant. Meanwhile, iRoot BP Plus does not contain bismuth oxide, which will not lead to discolouration of the teeth and has better aesthetics[6].

2. Information and Methods

2.1 General information

Sixty cases of caries-derived irreducible pulpitis in mature permanent teeth admitted to our hospital from March 2022 to November 2024 were selected for the study, and were randomly divided into the control group and the experimental group. The control group consisted of 30 cases, 18 males and 12 females, aged 19-56 years. The experimental group consisted of 30 cases, 16 males and 14 females, aged 20-58 years. The study was approved by the Ethics Committee, and the patients themselves and their relatives who participated in this experiment were aware of the contents of the experiment.

2.2 Inclusion and exclusion criteria

Inclusion criteria: (1) 18 years of age or older; (2) no history of systemic diseases; (3) diagnosis of caries-derived irreducible pulpitis based on clinical examination; (4) normal response to electro-physical vitality test (EPT) of the pulp; (5) restorable nature of the affected teeth; (6) no chronic periodontitis; (7) complete data.

Exclusion criteria: (1) teeth with immature roots; (2) teeth that cannot be directly restored; (3) uncontrollable bleeding within 10 min after pulpotomy; (4) patients with poor compliance and inability to cooperate with the treatment, and patients with serious mental or systemic diseases; (5) women who are lactating or menstruating during pregnancy; (6) patients whose teeth have received previous dental treatment; (7) patients with serious infectious diseases.

2.3 Methods

Both groups of patients were treated with pulpotomy, and the relevant surgery was completed by the same physician. Pulpotomy[7]: Do all the preoperative examinations and preparations, explain the surgical method to the patients and their families in detail, and obtain their co-operation. Preoperative analysis of the relationship between the caries cavity and the pulpal cavity was carried out by means of apical radiographs to assess the specific lesions. Intraoperatively, local infiltration anaesthesia was used to treat the affected teeth with ativanine-epinephrine injection. The pulp was opened by rubber barriers and strong saliva aspirators to isolate moisture and prevent staining, and the decayed material was removed, and the pulp roof was uncovered by the uncovering method, with the aid of a high-speed air turbine handpiece with a ball drill to cool and fully reveal the pulp chamber and reduce the irritation of the pulp. The crown pulp was removed with a sterile slow-speed handpiece and a large ball drill, and rinsed with saline to remove pulp fragments and debris from the dentin, and the pulp was observed and evaluated, and the amount and colour of bleeding was observed and recorded to assess the extent of the lesion. Wet cotton balls were placed on the pulpal section to stop bleeding sufficiently and wait for pulp capping.

Pulp capping treatment: control patients were given mineral trioxide aggregate (MTA) antibacterial paste to cap the pulp. The patients in the study group were given iRoot BP Plus root canal filling and restoration materials to cover the pulp.

2.4 Observation indexes

(1) Evaluation of treatment success rate: The two groups of patients were followed up for a period of 12 months after the operation, and the condition of the affected teeth was reviewed and evaluated at the stages of 3, 6, and 12 months after the operation, and the treatment success rate was evaluated on the basis of the results of the oral examination and imaging examination to understand the symptoms of the patient's complaints, tooth position, gingival condition, root development, and internal and external resorption of the tooth root, and the treatment success rate was evaluated on the basis of the results of the examination. The patients' teeth without hot and cold stimulation pain, spontaneous pain, tenderness, gingival swelling, no fistula, pulp vitality test is normal, no root resorption is successful, and any one of the above abnormalities is failure[8]. The statistics of 6 and 12 months after surgery included the number of failure cases in the previous stage. (2) Evaluation of the degree of root resorption: Evaluation of the degree of root resorption of the two groups of patients at the follow-up examination 12 months after the

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operation, using the commonly used clinical evaluation method, i.e., the ratio of the root resorption length to the total length of the tooth is evaluated, with no resorption as 0 degree, resorption of <25% of the length of the tooth is considered to be mild, resorption of the length of the tooth in the range of 25~<50% is considered to be moderate, and resorption of the length of the tooth of ≥50% of the length of the tooth is considered to be severe, and including the failure case[s][9]. (3) Adverse reactions: the incidence of adverse reactions such as infection, gingival damage, filling loss, and allergy were counted in patients during the follow-up period. The total incidence of adverse reactions is equal to the sum of the incidence of each adverse reaction.

2.5 Statistical method

All the collected values were entered into SPSS software to make statistical analysis, the count data were recorded as the number of cases and percentage, and analysed by the $\chi 2$ test, the measurement data were recorded as the mean and standard deviation, and analysed by the t-test, and the difference existed at the statistical level when $P<0.05$.

3. Results

3.1 Basic information

The distribution of cases by variable/category and bivariate analysis were presented. The size of perforation and apical foramen closure had a significant effect on the results ($P < 0.05$), while the gender and age of the patients did not have a significant effect on the results ($P > 0.05$), as shown in Table 1.

Table 1: Distribution of cases by variable/category and bivariate analysis [n(per cent)].

Factor		Failure	Success	P
Sex	male	4(11.76)	30(88.23)	0.072
	female	1(3.84)	25(96.15)	
Age	≤45	10(19.61)	41(80.39)	0.070
	>45	1(11.11)	8(88.89)	
Size of perforation (diameter)	<2mm	0(0.00)	54(100.00)	0.000
	≈2mm	4(66.67)	2(33.33)	
Apical foramen closure	closed	3(6.52)	43(93.48)	0.000
	Not closed	1(7.14)	13(92.86)	

3.2 Comparison of the treatment success rate of the two groups of patients at different stages after surgery

Comparison of the treatment success rates of patients in the two groups at 3, 6 and 12 months after surgery, the difference is not statistically significant (all $P>0.05$), see Table 2.

Table 2: Comparison of the degree of root resorption between the two groups [Case (%)]

Group	Number of cases	3 months after surgery		6 months after surgery		12months after surgery	
		Success	Failure	Success	Failure	Success	Failure
Control group	30	29(96.67)	1(3.33)	26(86.67)	4(13.33)	24(80.0)	6(20.0)
Experimental group	30	30(100.00)	0(0.00)	28(93.33)	2(6.67)	27(90.00)	3(10.00)
X^2		1.21		0.765		0.450	
P		0.271		0.382		0.503	

3.3 Comparison of the degree of root resorption between the two patients

Comparison of the degree of root resorption between the two groups of patients at 12 months after surgery, the difference is not statistically significant ($P>0.05$), see Table 3.

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Table 3: Comparison of the degree of root resorption between the two groups [Case (%)]

Group	Number of cases	0 degrees	Mild	Moderate	Severe
Control group	30	22(73.33)	6(20.00)	2(6.67)	0(0.00)
Experimental group	30	24(80.00)	5(16.67)	1(3.33)	0(0.00)
P	>0.05				

3.4 The occurrence of adverse reactions in the two groups of patients

Comparing the total incidence of adverse reactions in patients in the study group during the treatment period is lower than that in the control group, but the difference is not statistically significant (P>0.05), see Table 4.

Table 4: Comparison of the occurrence of adverse reactions in the two groups [Case (%)]

Group	Number of cases	Infection	Gum damage	Filling loss	Allergies	Total
Control group	30	2(6.67)	1(3.33)	1(3.33)	1(3.33)	5(16.67)
Experimental group	30	1(3.33)	1(3.33)	1(3.33)	1(3.33)	4(13.33)
X^2						2.216
P						0.137

4. Conclusions

Oral health problems are widely concerned by the society, and endodontic disease and dental caries are common, which can lead to tooth loss and tooth loss, hindering oral health. In dentistry, pulpectomy is often used to remove the lesion and retain the normal pulp tissue, which not only prolongs the retention time of the affected teeth, but also reduces the cost and number of treatments for the patients. It has been found that a decayed pulp does not mean that the bacteria have reached the pulp. Often, the softened dentin near the pulp contains bacterial products that have reached the pulp, but the bacteria themselves do not necessarily reach the pulp, which can be preserved to a large extent by direct pulp capping and crown pulpotomy[10]. Conservative pulp capping treatment creates a restorative barrier, the so-called calcified bridge, which protects the pulp tissue from microbial irritation[11]. Pulp capping agent is one of the important factors affecting the effect of pulp cutting treatment, and the ideal capping agent should have good biocompatibility, good sealing properties and good antimicrobial properties, which can promote tissue regeneration, be convenient for clinical manipulation, and have a certain compressive strength[12]. This experiment is mainly to study the effect of iRoot BP Plus in pulpotomy by comparing the use of iRoot BP Plus with MTA two such random to study the effect of iRoot BP Plus in pulpotomy.

The results of this study suggest that more direct clinical evidence can be provided for the use of iRoot BP Plus as a direct pulp capping to preserve living pulp. iRoot BP Plus does not differ from MTA in clinical application. By comparing the success rates of the two pulp capping agents at 3, 6, and 12 months after surgery, it was found that there was no statistically significant difference between the two capping agents (P>0.05); the difference in the degree of root resorption between the two groups was not statistically significant when comparing the two groups at 12 months after surgery (P>0.05); and the total incidence of adverse events during the treatment period of the patients in the study group was lower than that of the control group, but the difference was not statistically significant (P>0.05). This study shows that in the treatment of caries-derived irreducible pulpitis in mature permanent teeth by pulpotomy with iRoot BP plus, the size of the perforation hole and the closure of the apical foramen have a significant effect on the results (P<0. 05).

In conclusion, iRoot BP Plus can be used as a pulp capping agent for pulpotomy in the treatment of caries-derived irreducible pulpitis in mature permanent teeth, which is similar to the effect of MTA, and the results of both clinical applications are better. However, attention should be paid to the size of the perforation and the closure of the apical foramen during the procedure, and the treatment effect is better for perforation <2 mm.

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