

Clinical and Radiographic Observation of Permanent Teeth with Incompletely Formed Roots after Root Canal Therapy

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《Abstract》

A total of 33 teeth with 66 root canals were clinically diagnosed as irreversible pulpitis, and 38 teeth with 53 canals were diagnosed as apical periodontitis. Those 71 teeth had 119 root canals, with incompletely formed roots, and they underwent root canal therapy and filling using a formulation of calcium hydroxide and iodoform called Vitapex and were clinically observed for 30 to 1312 days. The following are the results and conclusions.

1. After root canal therapy, the condition of the root canal filling material was determined by radiograph. In 66 root canals with irreversible pulpitis, 16 cases were overfilled, 11 cases were flush and 39 cases were underfilled. In 53 cases with apical periodontitis, 28 cases were overfilled, 10 cases were flush and 15 cases were underfilled.
2. Clinical discomfort was experienced in 10 cases with irreversible pulpitis and in 3 cases with apical periodontitis. However, most of the discomfort was of a mild degree and disappeared within a week.
3. At the last observation, a high frequency of closure of the root apex was observed by radiograph. Cases with apical periodontitis tend to have a slight delay in inducing closure of the root apex compared with cases with irreversible pulpitis. However, after 540 days, closure of the root apex was observed in all cases.
4. Clinical and radiographic findings show that in 33 cases with irreversible pulpitis, 23 cases were good, 9 cases were fair and 1 case was poor. On the other hand, in 38 cases with apical periodontitis, 35 cases were good, 2 cases were fair and 1 case was poor.

Introduction

Incomplete removal of dental pulp allows for the continuous formation of the root. This is called pulpotomy and is commonly indicated for the treatment of vital pulp. However, infection of vital pulp may spread into the radicular pulp leading to necrosis and may form lesions at the root apex. Therefore, root canal treatment of infected pulp is a must. The application of calcium hydroxide has been recently used as root canal filling material in these cases [1-5].

The efficacy of calcium hydroxide formulation used as root canal filling material has long been known. Further, calcium hydroxide is known to induce closure of the root apex or narrowing of the root apex by inducing hard tissue formation. Incompletely formed roots in permanent teeth can be treated with a conventional root canal method, and the application of calcium hydroxide has been described in many case reports [6-13], clinical studies [14-29] and experimental studies [30-42] since 1970. According to those studies and reports, calcium hydroxide preparation is an effective root canal filling material for permanent teeth with incompletely formed roots.

In previous reports, calcium hydroxide formulation was combined with purified water, saline solution or CMCP to make a paste. However, when these pastes are applied in clinical practice, manipulation is not easy. Furthermore, the paste is not radiopaque, so confirmation of the condition of the root canal filling material after treatment is not possible.

This department conducted several pathological studies and proved the efficacy of calcium hydroxide-iodoform preparation called Vitapex as root canal filling material for permanent teeth with incompletely formed roots. Vitapex has superior radiographic contrast and has already been used in deciduous teeth [43-47], permanent teeth [48, 49] and experimental dog's teeth [50]. As a result, Vitapex turned out to be an effective root canal filling material in permanent teeth with incompletely formed roots. In this study, the authors report the clinical and radiographic findings of cases treated with Vitapex as root canal fill filling material in permanent teeth with incompletely formed roots diagnosed with irreversible pulpitis and apical periodontitis.

Examination methods

Subjects were 59 pediatric patients aged 7 years and 3 months to 13 years and 5 months who visited Tokyo Dental College Hospital, Department of Pediatric Dentistry. A total of 71 permanent teeth with 119 root canals with incompletely formed roots were diagnosed to be suffering from irreversible pulpitis or apical periodontitis. Specific clinical diagnoses of irreversible pulpitis were chronic ulcerative pulpitis, acute purulent pulpitis, tooth fracture caused by trauma, gangrenous pulpitis and those with apical periodontitis were acute purulent periodontitis and chronic suppurative periodontitis. Of these, 33 teeth with 66 root canals were treated with pulpectomy and 38 teeth with 53 root canals were treated with infected root canal treatment.

Root canal filling material used in this study was Vitapex with the following formulation:

Vitapex (per 100g)	
Calcium hydroxide (Japan Pharmacopoeia)	30.39g
Iodoform	40.4g
Silicone oil	22.4g
Others	6.9g

For cases with irreversible pulpitis, root canal filling was immediately performed after anesthesia and pulp extirpation. First, 2% Xylocaine local anesthesia, about 1-3 ml, was used for

pain relief. Then after, the tooth was isolated using a rubber dam, the area was cleaned and disinfected and 2 broaches were used to extirpate the pulp. Then the root canal was irrigated alternately with 10% sodium hypochlorite and 2% hydrogen peroxide solutions and dried with a sterile cotton plug. Without enlarging the root canal, Vitapex was applied as root canal filler.

Treatment of cases with apical periodontitis is as follows. These cases were symptomatic and root canals were opened for drainage. After complete removal of the root canal contents, the root canals were cleaned, dried and zinc oxide eugenol cement was used to temporarily seal the root canal. Thereafter, the patient was recalled after 1 week for cleaning of the root canal. When very few exudates were found in the root canal and all clinical symptoms had disappeared, root canal filling was performed using Vitapex. The root canal apex and root canal length were confirmed using electrical resistance (apex locator) with pre-operative radiograph as reference.

After root canal therapy, missing parts of the crown were restored to complete the treatment. Clinical and radiographic examinations were made for both groups. Specifically, patients were recalled regularly as much as possible for detailed observation and examination of signs and symptoms, as well as for radiographic examinations. Radiographs taken were standardized as much as possible to measure the self-designed imaging system using radiograph normalization.

Histopathological findings

Table 1 shows the clinical diagnosis and the number of cases surveyed from 71 permanent teeth with incompletely formed roots. Particularly, 17 cases were diagnosed with chronic ulcerative pulpitis, 1 case was diagnosed with acute purulent pulpitis and 15 cases were diagnosed with tooth fracture caused by trauma. Those 33 cases were treated with pulpectomy. On the other hand, 33 cases were diagnosed with chronic supportive periodontitis and 6 cases were diagnosed with acute purulent periodontitis and these cases were treated with infected root treatment. In addition, 1 case was diagnosed with gangrenous pulpitis but the treatment done was similar to those with apical periodontitis.

Table 2 shows the treatment, type of tooth and the number of cases. The most common tooth with irreversible pulpitis and apical periodontitis is the maxillary central incisor, occupying nearly half of the cases. The mandibular 1st molar is the second most treated tooth.

Table 3 shows the number of cases in each observation period. Observation periods ranged from 30 to 1312 days (about 3 years and 7 months).

Table 4 shows the number of cases and clinical discomforts observed, which include spontaneous pain, pain on mastication, gingival swelling, and pain on percussion. The degree of discomfort was classified into three levels of intensity as mild, moderate or severe according to

Table 1 Clinical diagnosis and number of cases

Clinical diagnosis	Number of cases
Chronic ulcerative pulpitis	17
Acute purulent pulpitis	1
Tooth fracture caused by trauma	15
Gangrenous pulpitis	1
Chronic suppurative periodontitis	31
Acute purulent periodontitis	6
Total	71

Table 2 Type of tooth and number of cases

Treatment		Type of tooth				
		Central inc	Lateral inc	1 st premolar	2 nd premolar	1 st molar
Upper	Pulpectomy	14	1	1	1	0
	Infected root canal treatment	19	0	2	0	0
Lower	Pulpectomy	0	0	0	4	12
	Infected root canal treatment	3	1	3	2	8
Total		36	2	6	7	20

Table 3 Observation period and number of cases

Observation period (days)	Number of cases	
	Irreversible pulpitis	Apical periodontitis
30~180	2	5
181~360	6	4
361~540	7	2
541~720	10	9
721~900	3	9
901~1080	4	4
1081~1312	1	5
Total	33	38

Table 4 Clinical discomfort

Clinical symptoms	Number of cases	
	Irreversible pulpitis	Apical periodontitis
Spontaneous pain	1	0
Pain on mastication	1	1
Pain of percussion	8	2
Gingival swelling	0	1

the authors' standards.

After root canal therapy in patients with irreversible pulpitis, 1 patient experienced spontaneous pain, 1 had pain on mastication, and 8 had pain on percussion. On the other hand, among patients with apical periodontitis, 1 experienced pain on mastication, 2 had pain on percussion, and 1 had gingival swelling. In 1 case with pain on mastication and percussion with irreversible pulpitis and 1 case with apical periodontitis, the discomfort was immediately relieved by root canal therapy. The duration of discomfort was less than a week, and all cases were mild.

Table 5 shows the condition of the root canal filling material observed by x-ray after treatment. Particularly, in 66 cases with irreversible pulpitis, 16 cases were overfilled, 11 cases were flush and 39 cases were underfilled. In 53 cases with apical periodontitis, 28 cases were

overfilled, 10 cases were flush and 15 cases were underfilled. Thus, underfilling is more likely to occur in cases with irreversible pulpitis and overfilling is more likely to occur in cases with apical periodontitis. In overfilled cases, the excess started to disappear a few days after, but it took nearly 2 months before it was completely resorbed.

Table 6 shows the radiograph of 53 cases with apical radiolucency. Apical radiolucency, observed in most cases, disappeared after 360 days.

Table 7 shows the number of cases with closed apex in each root canal until the last observation period. The number of cases with closed apex was frequently observed in both groups, although closure of apices with irreversible pulpitis was somewhat delayed compared to those with apical periodontitis. However, after 540 days, all cases had a closed apex.

Table 8 shows the summary of the clinical and radiographic findings.

The overall clinical and radiographic findings were determined using the following criteria:

Table 5 Condition of root canal filling material in radiograph (Number of root canals)

Condition	Irreversible pulpitis	Apical periodontitis
Overfilled	16	28
Flush	11	10
Underfilled	39	15
Total	66	53

Table 6 Periapical radiolucency

Observation period (days)	No of root canal	Periapical radiolucency		
		Lost	Reduced	Constant
30~180	9	7	1	1
181~360	4	3	1	0
361~540	2	2	0	0
541~720	11	11	0	0
721~900	16	16	0	0
901~1080	4	4	0	0
1081~1312	7	7	0	0

Table 7 Closure of the root apex

Observation period (days)	Irreversible pulpitis		Apical periodontitis		Total	
	No of RC	Closed apex	No of RC	Closed apex	No of RC	Closed apex
30~180	4	0	9	5	13	5
181~360	11	9	4	3	15	12
361~540	7	5	2	2	9	7
541~720	22	22	11	11	33	33
721~900	17	17	16	16	33	33
901~1080	4	4	4	4	8	8
1081~1312	1	1	7	7	8	8

Table 8 Overall results of clinical and radiographic findings

Grade	Irreversible pulpitis	Apical periodontitis
Good	23	35
Fair	9	2
Poor	1	1
Number of cases	33	38

Good: no discomfort throughout the observation period, radiograph shows tendency of closure of root apex, no hard tissue change around the root tip, in case with apical periodontitis, showed reduced or loss of periapical radiolucency, normal periodontal ligament space and lamina dura

Fair: with mild discomfort after treatment which disappeared within a week or moderate extent lost within 3 days or shorter duration, with tendency of closure of the apex, slight resorption of alveolar bone, in case with periapical infection, slight reduction in periapical radiolucency or no change during the initial visit, with a tendency towards healing

Poor: with unacceptable degree of discomfort after treatment, moderate degree which lasted for more than 4 days or mild discomfort sustained for more than 1 week, with soft tissue swelling, fistula or drainage, no tendency of closure of root apex, with destruction of alveolar bone in cases with irreversible pulpitis, deterioration of periapical radiolucency after the initial visit

From the above criteria, clinical and radiographic findings in 33 cases with irreversible pulpitis, 23 cases were good, 9 cases were fair and 1 case was poor. On the other hand in 38 cases with apical periodontitis, 35 cases were good, 2 cases were fair and 1 case was poor.

Below are typical examples of cases observed in this study with detailed clinical and radiographic findings.

Figure 1 shows the left mandibular second premolar in a 12 year and 1 month old girl at first visit diagnosed with chronic ulcerative pulpitis. After pulpectomy and root canal filling, overfilling of the root canal was confirmed from the radiograph. However, after 180 days, excess filling material had been resorbed and disappeared from the radiograph. In addition, after 912 days, closure of the root apex is seen in radiograph. This case was asymptomatic throughout the course of the observation period without any abnormal findings in radiography and closure of the apex was confirmed. Thus, clinical and radiographic results were determined to be good.

Figure 2 shows the left maxillary central incisor in a 7 year and 5 month old girl at her first visit one year after crown fracture due to traumatic injury. After pulpectomy and root canal filling, overfilling was confirmed from the radiograph. However, 56 days later, a tendency of resorption of the root canal filling material was observed by radiograph. In addition, after 982 days, root formation and closure of the root apex were observed. The case remained asymptomatic throughout the observation period and no abnormal findings were observed on radiographic examination. Thus, clinical and radiographic results were determined to be good.

Figure 3 shows the right mandibular first molar of a 9 year and 8 month old boy at his first visit diagnosed with acute purulent periodontitis. The treatment applied was infected root canal treatment. At the end of the initial visit, a localized apical radiolucency was seen upon x-ray. After root canal therapy, overfilling of root canal filling material was observed. After 89 days, a

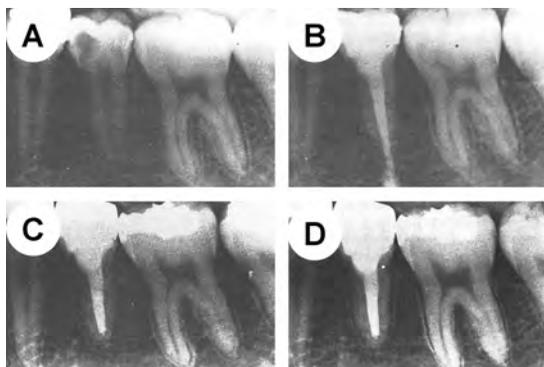


Figure 1 Case of pulpectomy (left mandibular 5), Age at the first examination: 12 years and 1 month. A: at the first examination; B: just after filling; C: 180 days after the filling; D: 912 days after the filling.

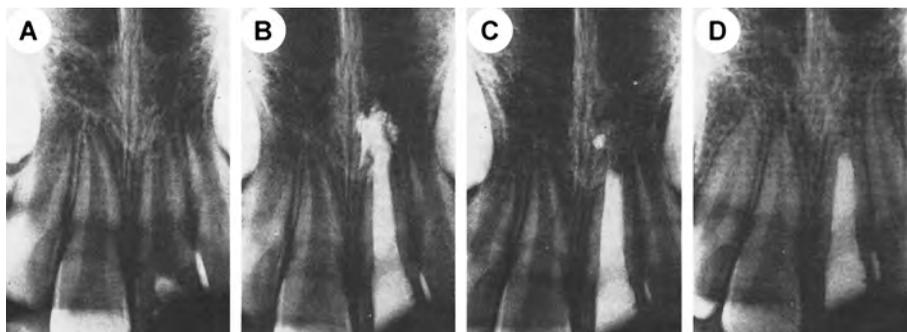


Figure 2 Case of pulpectomy (left maxillary 1), Age at the first examination: 7 years and 5 months. A: at the first examination; B: just after filling; C: 56 days after the filling; D: 982 days after the filling.

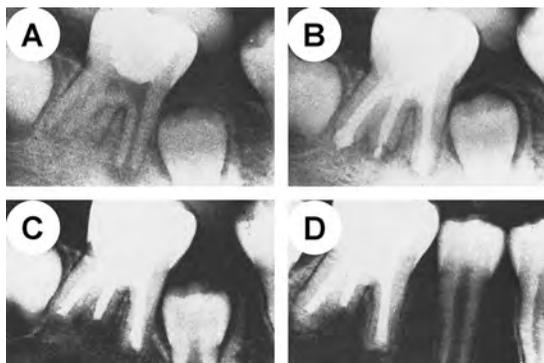


Figure 3 Case of infected root canal treatment (right mandibular 6), Age at the first examination: 9 years and 8 months. A: at the first examination; B: just after filling; C: 89 days after the filling; D: 846 days after the filling.

tendency for resorption of the excess root canal filling material was evident in the x-ray. In addition, after 846 days, excess filling material disappeared and closure of the apex was observed. This case had no symptoms until the last observation period and healing can be clearly observed by x-ray. Thus, clinical and radiographic results were determined to be good.

Figure 4 shows the right maxillary central incisor in a 7 year and 3 month old boy at his first visit after more than a month since he suffered from traumatic injury. The diagnosis was chronic suppurative periodontitis, and the case was treated with infected root canal filling. A diffuse apical radiolucency was observed at the end of the first visit. After root canal therapy, excess root canal filling material was apparent in the x-ray. However, after 199 days, excess filling material had been resorbed and disappeared on x-ray examination. Further, after 1084 days, an increase in radiopacity reminiscent of root growth was clearly observed in the periodontal ligament space around the root tip. This case remained asymptomatic until the last observation period, and x-ray showed good healing. Thus, clinical and radiographic results were determined to be good.

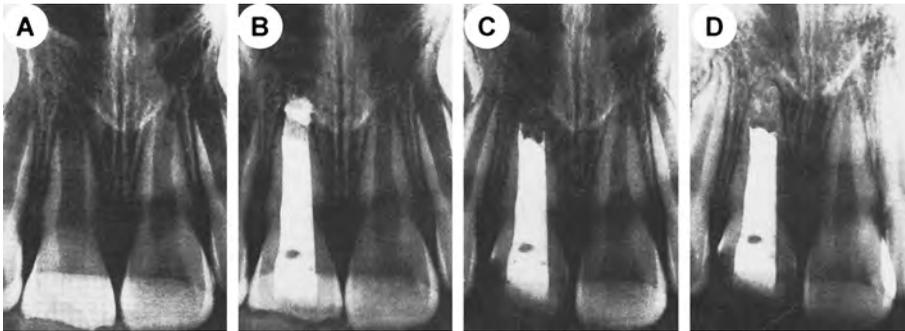


Figure 4 Case of infected root canal treatment (right maxillary 1), Age at the first examination: 7 years and 3 months. A: at the first examination; B: just after filling; C: 199 days after the filling; D: 1084 days after the filling.

Discussion

1 Teeth investigated in this study

Considering the type of tooth used in this study, the maxillary central incisor accounts for the most number of cases treated, followed by mandibular first molar. This is because the maxillary central incisor is most prone to injury and the mandibular first molar has the highest prevalence of caries.

Permanent teeth with incompletely formed roots investigated in this study were suffering from disease, which led to dental pulp disease, or apical periodontal disease, crown fracture from trauma, caries, hypoplasia with central tubercle in premolar (Leong's premolar) etc. Trauma accounted for the majority in anterior teeth while caries accounted for the majority in the posterior region, especially in first molar. In many cases, more immature roots were found in maxillary central incisors than in mandibular first molars with regard to individual tooth.

Trauma and fracture of the central tubercle in premolars occurred spontaneously, which resulted in radical caries formation. Thus, if one will consider the cause of progression, it seems to be due to the difference in the degree of root formation.

As a result, the opportunity to apply root canal therapy with incompletely formed roots is most often in the maxillary central incisor in contrast to the previously known mandibular first molar. Thus, there is less chance to perform root canal therapy with incomplete roots in

mandibular first molars than in maxillary central incisors.

2 Condition of the root canal filling

The condition of the root canal filling in both groups after treatment was confirmed. Cases were permanent teeth with incompletely formed roots, and a widely open apex filled with soft tissue. The shape of the apex and the presence of soft tissues are thought to affect the condition of the root canal filler. In cases with irreversible pulpitis, residual pulp may be present at the apical portion and in cases with apical periodontitis. The excess root canal filling material induces granulation tissue formation since overfilling is common in roots with open apex. This has also been observed in animal studies [40, 41]. Although the root apex tends to affect the prognosis of the condition of the root canal filling material, it cannot be generalized at this point.

3 Clinical findings

Many cases of clinical discomfort were noted in cases treated with pulpectomy. Most of these, however, disappeared after 1 week. When the root is incompletely formed and wide, pulp extirpation with the addition of the root canal filler is believed to easily induce discomfort during treatment. Thus, in such cases, after pulp extirpation, obturation may not be performed immediately and can be postponed until the next appointment to prevent the occurrence of discomfort brought about by the treatment.

4 Closure of the apex

The lastradiograph observation period showed a high incidence of closure of the apex in both groups. However, closure of the apex was slightly delayed in cases with irreversible pulpitis than in cases with apical periodontitis.

We reported the mechanism for the closure of the root apex in permanent teeth with incompletely formed roots treated with calcium hydroxide in clinical observation [7, 14]. If treatment is appropriate, functional recovery of Hertwig's epithelial root sheath seems to continue root formation. In contrast, research reports carried out in animal experiments have had a negative opinion regarding the involvement of Hertwig's epithelial root sheath [33, 38]. Pathological studies performed in dog teeth and in patients with vital pulp [50] observed the indication of root growth. However, in the absence of vital pulp, the addition of new hard tissue at the root apex was observed.

In this experiment, periapical inflammation present in a case as shown in Figure 4 is reminiscent of root growth, which was also observed in a number of cases through radiographs. Clinically, the case was diagnosed as non-vital teeth, but histologically, remaining pulp was thought to induce hard tissue formation along the root end. Therefore, even if the clinical and radiographic diagnosis is apical periodontitis, the possibility of residual vital pulp may still be present at the root apex.

5 Overall clinical and radiographic scores

Clinical and radiographic scores for both groups were extremely good. Specifically, only 2 out of 71 (2.8%) cases were given a score of poor, and in those 2 cases after appropriate treatment, the expression of discomfort was negligible. Further consideration regarding the indication of this method for use in permanent teeth is suggested.

The clinical results of this study have already been reported in other studies [7-9, 14, 15]. If closure of the apex can be observed after treatment, it is recommended that solid root canal filling materials like gutta percha should be used. However, there are insufficient reports

concerning this idea. Moreover, animal studies conducted by the authors [50] obtained good results regardless of the length of the observation period. Therefore, the authors think that during crown restoration, the use of solid material should not be considered as root canal filling material unless a silver point is used. However, to arrive at this conclusion, a longer observation period would be needed.

Conclusions

The authors performed root canal therapy on permanent teeth with incompletely formed roots; 33 were diagnosed to have irreversible pulpitis and 38 cases were diagnosed to have apical periodontitis. Each case underwent root canal therapy and filling using Vitapex and was observed.

As a result, clinical and radiographic findings were good for both groups. Thus, the clinical value of this method was considered during root canal therapy of permanent teeth with incompletely formed roots.

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