Management of wide open apices in non-vital permanent teeth with $Ca(OH)_2$ paste

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A retrospective study on 15 non-vital immature incisor teeth was done using $Ca(OH)_2$ Pulpdent® paste. A success rate of 100 percent was achieved within one year. The variables influencing the time taken for apexification were also evaluated. The teeth were followed up to a period of 24 months. It was found that older children having narrow open apex had a shorter treatment time than the younger children (NS); teeth without periapical infection showed some amount of root growth and closing of apex that was faster than those with periapical infection ($p<0.001$). The calcified bridge formed following apexification is a porous structure. This investigation provides information about the time taken and procedure required to achieve apical barrier formation in non-vital immature incisors.

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INTRODUCTION

Endodontic management of non-vital young permanent teeth is often complicated. The walls of the root canals are frequently divergent, the apices open, thereby making debridement and obturation difficult. This involves placing $Ca(OH)_2$ paste into the root canal space after proper biomechanical preparation and appropriate disinfection of the root canal. The procedure/process is well recognized and accepted by clinicians as well as researchers as "apexification".[1-3] It involves a hard tissue barrier formation at the apex against which gutta percha can be condensed. A number of studies have been done using different commercially available $Ca(OH)_2$ products viz. Reogen Rapid (Vivadent), Pulpdent® (Pulpdent Corp.), Calasept (Scania Dental, Stockholm), Calcicur (Voco) etc.

In the unit of Pedodontics and Preventive Dentistry, Department of Oral Health Sciences, PGIMER, Chandigarh, Reogan Rapid (Vivadent) has been primarily used for apexification cases to initiate the bridge formation. Chawla,[4] Mackie,[5] has reported One hundred percent success, with Reogen Rapid.[5] Because of non-availability of this material for some period in the department, the alternate material Pulpdent® was used for apexification. There is a constitutional difference in the above two materials; Reogan Rapid contains calcium hydroxide, barium sulfate, calcium oxide, magnesium oxide, casein and distilled water, whereas, Pulpdent(consists of only calcium hydroxide, methyl cellulose and barium sulfate. Therefore, a retrospective study of fifteen cases was planned to determine the effectiveness of Pulpdent® paste in inducing apical barrier formation (ABF). The study also evaluated various factors that influence the time taken for apexification.

MATERIALS AND METHODS

The study was conducted on twelve children aged seven to sixteen years involving fifteen incisors, 12 central incisors and 3 lateral incisors. The children were selected from those seeking treatment for traumatic injuries of anterior teeth at the unit of Pedodontics and Preventive Dentistry, PGIMER, Chandigarh.

The selection criteria included: discolored, non-vital, permanent anterior teeth with open apices, in accordance with Nolla's stage 8 or 9.[6] Assessment of the teeth was done clinically using radiographs and an electric pulp tester. After the clinical and radiographic assessment, the child was prescribed antibiotics, if required, for the relief of acute symptoms.

In the first appointment, local anesthesia was administered and tooth isolated with rubber dam. An access

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Table 1. Relationship of Apexification with Time

Total Teeth with Apexification	Teeth without PA infection (11)						Teeth with PA infection (4)					
	Time required for Apexification (mths)											
	2	4	6	8	10	12	2	4	6	8	10	12
15	1	5	4	1	-	-	-	-	-	3	1	-

t-value=-4.0547, p-0.0007
p<0.001, Highly Significant

Table 2. Split up - Apexification according to no. of pulpdent dressings required.

Total Teeth with successful Apexification	No. of pulpdent dressings required for Apexification		
	1 Dressing	2 Dressings	3 Dressings
15	6 (40%)	6 (40%)	3 (20%)

cavity prepared so that a straight line of entry into the canal was achieved. This must be sufficiently large to enable proper instrumentation of the canal walls, which may be divergent in the apical area. In the same sitting, a diagnostic radiograph was taken to establish working length of the canal. No particular attempt was made to strictly keep the reamer inside the periapex.

The debridement of root canal was done with reamers and files, avoiding injury to the periapical area, along with 5% hypochlorite irrigating solution. In the second appointment, additional biomechanical preparation was done and then irrigated again with hypochlorite followed by metronidazole solution.

Introduction of Pulpdent® paste

The patient was then reclined with chin raised so that the coronal end of the root canal was higher than the apical end, thus facilitating the flow of $Ca(OH)_2$ to the apex.[4] Pulpdent® paste was pushed into the root canal using either reamer or hand driven lentulo spiral by rotating clockwise, while inserting the instrument into canal and then pushing the paste apically several turns followed by anti-clock wise removal of the instrument from the canal. This method ensures that the $Ca(OH)_2$ paste reaches the apex of the root canal.

Excess $Ca(OH)_2$ paste from the chamber was removed by the excavator. The coronal end of the canal was sealed with reinforced ZnOE. The teeth were then evaluated after every two months, clinically, and radiographically.

$Ca(OH)_2$ paste was replaced after two months, only, if it were resorbed in apical 1/3rd of the root canal. This was done until apical closure occurred.

Clinical assessment

Patient would be free from symptoms of pain and tenderness and apical closure would have occurred. The apical barrier formation (ABF) was determined by introducing a gutta percha cone into the canal and slowly tapping it with a finger toward the apex.[4] If an obstruction was met without eliciting pain, it was presumed to be caused by a calcified bridge and not because the gutta percha was striking against bone.

Radiographic assessment

Healing of periapical lesion, if present, was seen with the appearance of lamina dura and bridge formation (calcified apical closure) on the radiograph.

RESULTS

This study encompasses the results of apexification procedure done in fifteen non-vital young permanent incisors in twelve children and followed for a period of 3 to 24 months. Apexification was achieved in all the fifteen cases within a year.

Out of fifteen teeth, eleven were without periapical infection and four were with periapical infection. The average time required for apexification in teeth without periapical infection was 4.9 ± 1.64 months, while for teeth with periapical infection, the corresponding time period was 8.5 ± 1.00 months. The difference was highly significant at 0.1 percent level ($p<0.001$) (Table 1).

Observations were made after every two months and it was found that 6 teeth required only one $Ca(OH)_2$ dressing for apexification, while another 6 required two dressings and in remaining 3 cases, it required three $Ca(OH)_2$ dressings for calcified barrier

Table 3. No. of Pulpdent® dressings required for apexification.

Tooth status	One dressing	Two dressings	Three dressings	Mean (S.D.)
Without PA infection (11)	6	4	1	1.5 (0.69)
With PA infection (4)	—	2	2	2.5 (0.58)

t-value=-2.4531, p=0.0143
p<0.05, Significant

Table 4. Time required for ABF (in months).

Age group	n	Mean time taken for ABF (months)
7-11 years	7	7.0
12-16 years	8	5.0

t-value=1.7468, p=0.0521
Non-significant

to occur (Table 2). When number of Pulpdent® dressings required for teeth without periapical infection were evaluated, it was found that out of 11 teeth,[6] required one dressing, 4 teeth required two dressings, while 1 tooth required three $Ca(OH)_2$ dressings for apexification and the mean number of $Ca(OH)_2$ dressings required in teeth without periapical infection was 1.5 ± 0.68.

Out of 4 teeth with periapical infection, 2 teeth required two and other 2 required three Pulpdent® dressings for apical closure, the mean number of dressings being 2.5 ± 0.57. The difference in the mean number of Pulpdent® dressings required for apexification in teeth with and without periapical infection was significant at 5 percent level ($p<0.05$) (Table 3). The mean time required for ABF in younger age group (7 to 11 years) was 7.0 months, while for older age group (12 to 16 years) it was 5.0 months, the difference being statistically non-significant (Table 4).

DISCUSSION

The formation of apical barrier in all the fifteen teeth proves the effectiveness of Pulpdent® paste in apexification procedures. Majority of the studies has reported high success rate using different $Ca(OH)_2$ pastes for apexification. Heithersay[7] used $Ca(OH)_2$ and methylcellulose in 21 teeth and achieved apical closure in 90 percent of the teeth in the time range of 14 to 75 months.

Chawla[4] treated 26 non-vital teeth using Reogen Rapid paste and the success rate was 100 percent with 35 percent teeth showing apical closure in twelve months and 65 percent teeth in six months.

Thater[8] used Pulpdent® paste in 34 teeth, but achieved a lower success rate of 74 percent as compared to 100 percent in our study. However, Kleier[9] achieved 100 per cent success rate as achieved in the present study using Pulpdent® paste on 48 teeth within 1 to 30 months.

Mackie[5] used both Reogen Rapid and Hypocal on 19 teeth each for apical closure and achieved 100 per cent success using both the brands with the mean time period of 6.8 months for Reogen Rapid and 5.1 months for Hypocal respectively.

There are various factors that influence the time taken for apical barrier formation (ABF):

1. Size of the apical foramen at the start of treatment – Teeth with apices < 2 mm in diameter have significantly shorter treatment times (Figures 1 and 2).
2. Age - May be inversely related to ABF time. Since less calcified material would be needed to occlude a narrow apex as compared to wide apex, it is understandable that the former would require shorter period for apexification. In the study conducted by Mackie,[10] patients, who were 11 years and older had significantly shorter treatment times. In the present study also, the mean time required for ABF in younger age group (7 to 11 yr.) was 7.0 months, while for older age group (12 to 16 yr.) it was 5.0 months (Table 4).
3. Infection - Some studies have reported that presence of periapical radiolucency at the start of treatment, increases the barrier formation time,[11] whereas others have not.[12] In the present study, the former holds true. In teeth without periapical infection, the aver-

Figure 1. Tooth (#21) with open apex.

Figure 2. Same case as in Figure 1 after obturation with only single calcium hydroxide (Pulpdent Corp.) dressing. Bridge formation with root growth has occurred. Sealer (ZnOE) gone beyond the bridge into the periapex.

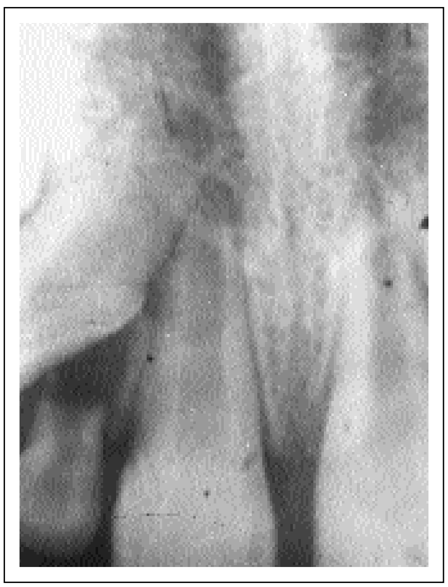

Figure 3. Tooth (#11) with open apex and periapical radiolucency.

age time required for apical closure was 4.9 months, while those with periapical radiolucency, the corresponding figure was 8.5 months. The presence of periapical infection also determines the number of dressings required for the apexification (Table 3).

4. Inter-appointment painful symptoms - May delay time taken for apical healing.[9]
5. Frequency of $Ca(OH)_2$ dressings - There is no census on how frequently $Ca(OH)_2$ should be changed to induce apical healing. In the present study calcium hydroxide paste was replaced, if it has resorbed in the apical one third of the root canal until apical barrier formation is complete.[13]

The continuous absorption/depletion of $Ca(OH)_2$ paste from the root canal suggests that it be continuously used in the formation of the bridge. The mechanism by which $Ca(OH)_2$ acts in the formation of the bridge is still not fully understood.

Alkaline pH and calcium ions might play a part either separately or synergistically. The calcium required for the apical bridge formation comes through the systemic route as demonstrated by Sciaky and Pisanty,[14] Pisanty and Sciaky[15] using radiolabled $Ca(OH)_2$.

However, Holland[16] described *in vivo*, a phenomenon when calcium carbonate crystals were produced by a reaction between the carbon di-oxide in the pulp tissues and the calcium of the capping material. Schroder and Granath[17] showed that OH ions induced the development of a superficial necrotic layer acting as a surface to which the pulpal cells gets attached, leading to bridge formation.

There are two types of biological repairs that have been described in the literature following apexification: (1) continued root growth,[18] and (2) occlusion of apex with calcified material.[19]

In the present study, in few teeth without periapical pathology, root growth was appreciated to some extent. (Figures 1 and 2) This could be due to the stimulation of the undifferentiated mesenchymal cells of the pulp and periapical tissues to form the odontogenic layer.[20] While in teeth with periapical pathology, no root growth was seen (Figures 3-6). There are conflicting views regarding the structure of calcified bridge.[11,17,20]

According to one school of thought, the bridge is a solid structure, consisting predominantly of the cemen-

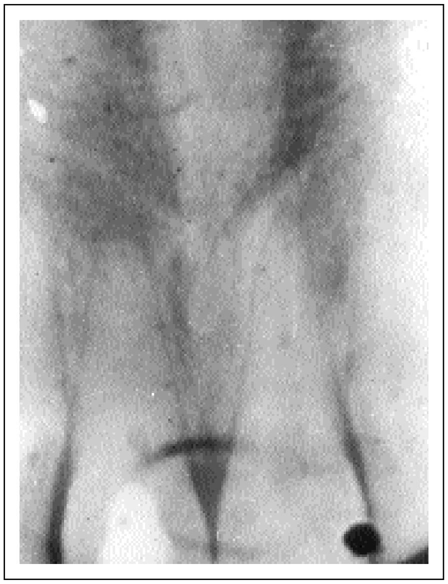

Figure 4. Same case as in Figure 3 showing canal filled with calcium hydroxide paste.

Figure 5. Same case as in Figure 3 after 2 months of filling calcium hydroxide. The paste has resorbed in apical 1/3rd, appearance of lamina dura and healing of PA lesion.

toid tissue,[21] while others are of the opinion that bridge is porous with loose connective tissue inclusions in between.[22,23]

It was seen in one of our cases following apical closure, the sealer (ZnOE) used along with gutta percha for obturation had extruded beyond the bridge (Figure 2). If the calcified bridge would have been a solid structure, the sealer could not have gone in the periapex. The bridge formed, therefore is a porous structure.

CONCLUSIONS

1. Calcium hydroxide paste (Pulpdent Corp) is an effective agent for apexification.
2. Presence of periapical pathology increases the time for apical barrier formation.
3. Teeth in younger age group take lesser time for apexification.
4. Calcified bridge formed following apexification procedure is a porous structure.
5. Concomitant root growth may be associated with absence of periapical radiolucency.

Figure 6. Post obturation radiograph. No root growth, but calcific apical closure has occurred.

Note: Teeth have been numbered according to FDI notation system.

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