DOI: 10.21276/aimdr.2019.5.5.DE8

Original Article ISSN (O):2395-2822; ISSN (P):2395-2814

Revascularization in Anterior Teeth with Immature Apices.

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Received: August 2019
Accepted: August 2019

ABSTRACT

Background: Treatment of immature teeth with necrotic pulp is a difficult procedure because of difficulty in obtaining fluid tight seal with normal root canal treatment. Revascularization may be considered as a treatment option in such teeth because of the stem cells present inside may help in closure of open apex by differentiating into cells required for root formation. **Methods:** 35 patients with history of trauma to upper front teeth were included in the study. For pulp regeneration procedure, bleeding was induced in canal and was allowed to clot over 15 min period to a level 3mm below CEJ coronally and was sealed off with MTA. Patients were followed up for period of 09 months to observe changes in pulp sensibility, increase in root length and increase in dentinal wall thickness. The obtained data was statistically analyzed. **Results:** There was significant increase in root length and dentinal wall thickness after the procedure. **Conclusion:** The results conclude that pulp regeneration procedure may be considered as a treatment option for patients with immature apices following trauma.

Keywords: Regeneration, Revascularization, MTA, Root Apex

INTRODUCTION

The trauma to anterior maxillary teeth is most commonly found among young children. The reason for such injuries is the position of maxillary teeth in upper jaw which makes them vulnerable to trauma. In many instances, such trauma leads to the cessation of root growth. Teeth of young children with trauma presents with incompletely formed root apices because of necrosis of pulp before root completion.[1-3] Treating such nonvital teeth with open apices poses many challenges like during biomechanical preparation step of root canal treatment, the weakened dentinal walls of such teeth can break. Similarly obturating such teeth requires use of special customized gutta-percha cone which might not provide adequate seal at apex and there is always a possibility of root getting break by the forces applied during obturation.[4-6]

Traditionally, treatment of such teeth involves placement of paste of calcium hydroxide inside teeth canal to induce apexification which will form a calcific obstruction at the apex.[1] But use of paste of calcium hydroxide inside the canal for a longer period can make dentinal walls of root weak and more prone to fracture.[2] Other treatment options available are periapical surgery, root canal treatment with customized gutta-percha and Mineral Trioxide Aggregate (MTA) barrier at apex.[3] Conventional root canal technique is successful for the treatment of apical periodontitis but it does not reinforce root structure of teeth. So cases with thin dentinal walls and open apex are always at risk of getting fracture after root canal treatment making it a nonviable treatment option for such teeth.[7-9]

A procedure called revascularization has been introduced for the closure of incomplete root apex in nonvital teeth. Ostby,[4] Rule and Winter5 showed the continuation of root growth and subsequent closure of root apex in children with pulpal necrosis. In 1972 Ham et al,[6] showed closure of apex after revascularization procedure in teeth with open apices in monkeys. Iwaya,[7] Banchs and Trope8 showed the superiority of regeneration treatment over calcium hydroxide based apexification on the basis of postoperative radiographs.[10]

The idea behind the regenerative procedure is that it develops tissue inside the canal of the tooth which stimulates PDLSC and SCAP present in the periapical region of tooth. This starts laying down of

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cementum and dentine like tissue around incomplete root with subsequent closure of open apex9. Revascularization procedure can be considered for treating such non vital teeth as it has shown in many cases continued root growth and subsequent closure of apices.[11-13]

MATERIALS & METHODS

Subject population

Over a period of 1.5 years, 35 patients who reported with complaint of trauma to maxillary anterior teeth and required rehabilitation for the same were included in the study. All patients were explained the rehabilitation procedure and informed consent was obtained before starting in the study. Approval of Ethics Committee was also taken. Patients were selected on basis clinical and radiographic evaluation and following inclusion and exclusion criteria:-

Inclusion criteria:

1. Patients (male or female) within the age group of 08 to 16 years
2. History of trauma with 03 months of reporting to department.
3. Apical diameter of tooth should be greater than 1.5 mm at the time of reporting.
4. Tooth should be non-vital at the time of reporting i.e negative response to pulp sensibility tests.

Exclusion criteria:

1. Luxated teeth
2. Sub luxated teeth
3. Teeth with radicular fracture.
4. Teeth with coronal fracture (Ellis Class III)

Clinical parameters:

Assessment of pulp sensibility was done using Electric Pulp Tester (Digitest II, Parkell USA). For assessment the tooth was isolated with the help of cotton roles. After drying the tooth, a conducting material was placed over tooth surface. The ground electrode of pulp tester was hooked over the lip of patient to complete the circuit. Then the tip of electric pulp tester was touched with tooth surface with conducting paste in between and reading was recorded for sensory response.

Radiographic- assessment and measurements:

Intraoral periapical radiographs were taken preoperatively to assess the apical constriction, length of root and width of dentinal walls following a standardized technique. A commercially available film holder and tube aligning system i.e. XCP positioning system (Dentsply Rinn) was used to minimize the geometric errors of film placing and tube alignment). Radiographs were taken using Kodak E-speed X-ray film and a radiographic grid with 0.5mm inter linear distance (Bluedent, India) both pre-operatively, post-operatively and at the end of 09 months. Then image of IOPA radiographs were taken with the help of a high resolution cameraover view box and transferred to the computer. After contrast enhancement on coral draw software, the linear measurement were done with the help of image tool 3 software. All the measurements were done by a single observer to prevent inter observer error.

Various materials used for the study are:

SL No.	Material	Manufacturer
1	MTA	Dentsply Maillefer
2	Metapex	Meta Biomed, South Korea.
3	Sodium Hypochlorite 2.5%	Prime Dental
4	Normal Saline	Nirma Nirlife
5	Inj Lignospan	Septodont, USA
6	Absorbent Paper Points	Meta
7	No. 25 K Files-25mm	Mani
8	IOPA films	Kodak , New York
9	Rubber Dam Sheets	GDC India
10	Composite resin (Z 350 XT)	Dentsply

Armamentarium:

SL No.	Armamentarium	Manufacturer
1	Mouth mirror	GDC India
2	Straight Probe	GDC India
3	Explorers	GDC India
4	Rubber Dam Kit	GDC India
5	Disposable Syringe(5 ml)	NuLife devices
6	Electric Pulp Tester	Parkell USA
7	IOPA X Ray Machine	Prox Digimed
8	Radiographic Grid	Bluedent,India
9	X-ray Positioning Device	Dentsply Rinn

Procedure:

The tooth concerned was isolated with the help of cotton rolls. Readings of pulp sensibility test were recorded. After pulp sensibility test, adequate anesthesia was obtained by administering infiltrative anesthesia with 2% Lignocaine with 1:80,000 Adrenaline. Isolation of tooth was done with the help of rubber dam. Access opening was done with round bur for initial ditch followed by tapered bur for entry in pulp chamber. Due to thin dentinal wall thickness, no instrumentation was done. Protocol of large amount of irrigation (2.5% sodium hypochlorite & saline) was followed. After this canal disinfection was done using intracanal medicament. Metapex (Meta Biomed) was used for disinfection of canal. After two weeks, medicament was washed out with saline and canal was dried. A sterile 25 no K file was introduced into the periapical area to irritate the periapical tissues. Bleeding thus induced was allowed to clot over 15 min period upto 3mm below CEJ coronally. 3mm of MTA was inserted into canal to seal off the clot and access was closed with temp restoration. After 24 hours temporary restoration was replaced by composite restoration.

Post-operative evaluation by clinical and radiographic methods

Post operatively; all the patients were evaluated for clinical parameters using electric pulp tester (EPT). Sensory response was recorded at 0,1,3,6 & 9 months using EPT.

A negative response till the end of 3 months was termed negative and patient was resorted to conventional apexification procedure.

Radiographic assessment was done at 0 months and 09 months for

1. Increase in root length
2. Increase in dentine wall thickness

Increase in root length evaluation:

IOPA radiographswere taken preoperatively and at 09 months post operatively. For this radiographic grid of 0.5mm interlinear distance (Bluedent, India) along with periapical film (Kodak, Germany) was held parallel to the length of tooth using film-holding device. The central ray was directed to pass at a perpendicular angle to both the tooth and the film. Exposures, developing and fixing was done by the same operator under standardized protocols. The grid lines and x-ray positioning device ensured that radiograph was standardized. After this images of IOPA radiographs were taken with a high resolution camera. Images of IOPA radiograph were transferred to a computer loaded with Corel DRAW software. With the help of coral draw software contrasts of images were adjusted. Then images were studied with the help of Image Tool 3 software. Linear distance measurements were made from radiographic CEJ to radiographic root apex. The distances were measured at 0 months and 9 months. Both initial and final root length documented.

Increase in dentine wall thickness evaluation:

IOPA radiographs were taken preoperatively and at 09 months post operatively. The dentinal wall thickness at 0 & 9 months was calculated at the level of the apical one third of length at 0 months from cementoenamel junction. Data collected was statistically analyze.

RESULTS

The study comprised of 30male and 05 female patients and the age of the patients ranged from 08-11 years. This study was taken up for clinical and radiological evaluation of pulp regeneration in maxillary anterior teeth with immature apices following trauma. Post operatively all the subjects were evaluated with the following parameters:

1. Pulp Sensibility
2. Increase in root length
3. Increase in dentinal wall thickness

1. **Pulp Sensibility**

The readings were recorded preoperatively and postoperatively at the end of 1, 3, 6 and 9 months [Table 1]. All teeth showed negative response to electric pulp test at 0 month and 1 month. After the end of 3 months only 11 patients showed the positive response to electric pulp test and rest 24 patients showed negative response. So these 24 patients were not considered for the rest of study and were treated with standard apexification procedure. At the end of 6 months only one patient showed some reading on tester. At the end of 9 months only 1 out of 11 patients showed positive response to electric pulp test. Inference of the study obtained was that only 31.4% of patients showed some form of sensibility response to electric pulp test at end of 03 months. At the end of 11 months only 0.35% showed positive response indicating that there was no significant sensory development after revascularization procedure.

2. **Increase In Root Length**

Increase in root length was considered as indicator for regeneration of pulp in non-vital immature tooth that was treated with revascularization procedure. Only 11 patients were considered. Root length was measured preoperatively and at of 09 months postoperatively. The increase in length of the patients ranged from 0.5-1 mm [Table 2]. Mean root length preoperatively was 10.59 mm for 11 patients and mean root length at 09 months was 11.09 mm for 11 patients. It is clear from the values that the root length has increased from the baseline to nine months. On statistical evaluation there was highly significant difference in root length at the end of 09 months (p value-.001) [Table 4].

3. **Increase In Dentinal Wall Thickness**

Increase in thickness of dentinal wall was considered as indicator for regeneration of pulp in non-vital immature tooth that was treated with revascularization procedure. The increase in thickness of dentinal walls of the patients ranged from 0.5-1 mm [Table 3]. Mean dentinal wall thickness preoperatively was 1.55 mm for 11 patients and mean dentinal wall thickness at 09 months was 2.0545 mm for 11 patients. It's clear from the values that the dentinal wall thickness has increased from the baseline to nine months. On statistical analysis the increase in dentinal wall thickness came out to be highly significant (p value-.001) at the end of 09 months [Table 4].

All results indicates that there is significant formation of root apex in non-vital maxillary anterior teeth with open apex after regenerative procedure is induced in them.

Table 1: Pulp Sensibility

Patient no	EPT at 0 Months	EPT at 01 Months	EPT at 03 Months	EPT at 06 Months	EPT at 09 Months
1	-	-	-	-	-
2	-	-	-	-	-
3	-	-	+	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	+	-	-
8	-	-	+	-	-
9	-	-	-	-	-
10	-	-	+	-	-
11	-	-	-	-	-
12	-	-	-	-	-
13	-	-	-	-	-
14	-	-	-	-	-
15	-	-	-	-	-
16	-	-	+	-	-
17	-	-	-	-	-
18	-	-	+	+	-
19	-	-	-	-	-
20	-	-	-	-	-
21.	-	-	-	-	-
22.	-	-	+	-	-
23.	-	-	-	-	-
24.	-	-	+	-	-
25.	-	-	-	-	-
26.	-	-	-	-	-
27.	-	-	-	-	-
28.	-	-	+	-	-
29	-	-	-	-	-
30	-	-	+	-	-
31	-	-	-	-	-
32	-	-	-	-	-
33	-	-	-	-	-
34	-	-	-	-	-
35	-	-	+	-	+

Table 2: Increase in root length

Patient no	RL at 0 Months(mm)	RL at 09 Months(mm)	Increase in Length(mm)
1		-	-
2	-	-	-
3	10.00	10.75	0.75
4	-	-	-
5	-	-	-
6	-	-	-
7	11.00	11.50	0.50
8	09.50	10.50	1.00
9	-	-	-
10	10.50	10.50	0.00
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
16	09.50	09.50	0.00
17	-	-	-
18	12.00	12.50	0.50
19	-	-	-
20	-	-	-
21.	-	-	-
22.	11.00	11.50	0.50

23.	-	-	-
24.	11.50	11.50	0.00
25.	-	-	-
26.	-	-	-
27.	-	-	-
28.	10.00	10.75	0.75
29	-	-	-
30	09.00	09.50	0.50
31	-	-	-
32	-	-	-
33	-	-	-
34	-	-	-
35	12.50	13.50	1.00

Table 3: Increase in dentinal wall thickness

Patient no	Dentinal Wall Thickness at 0 Months (mm)	Dentinal Wall Thickness at 09 Months(mm)	Increase in Thickness(mm)
1		-	-
2	-	-	-
3	1.50	2.25	0.75
4	-	-	-
5	-	-	-
6	-	-	-
7	2.00	2.50	0.50
8	1.70	2.70	1.00
9	-	-	-
10	1.80	1.80	0.00
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
16	1.60	1.60	0.00
17	-	-	-
18	1.40	1.90	0.50
19	-	-	-
20	-	-	-
21.	-	-	-
22.	1.20	1.70	0.50
23.	-	-	-
24.	1.50	1.50	0.00
25.	-	-	-
26.	-	-	-
27.	-	-	-
28.	1.80	2.55	0.75
29	-	-	-
30	1.20	1.70	0.50
31	-	-	-
32	-	-	-
33	-	-	-
34	-	-	-
35	1.40	2.40	1.00

Table 4: Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	RL at 0 Months - RL at 09 Months	-.50000	.37081	.11180	-.74911	-.25089	-4.472	10	.001**

DISCUSSION

The root canal treatment is done for treating of pulpal diseases including pulpal necrosis, periapical abscess, apical periodontitis or irreversible pulpitis to obtain a fluid tight seal at root apex to prevent further ingression of infection into periapical area. Similarly the goal for the treatment of nonvital incomplete formed teeth is to restore its physiologic structures and functions. But to achieve a fluid tight seal in such cases with open apices and the non-developed roots is very difficult using conventional root canal treatment.[14,15]

There are several approaches to treat such cases of open apices like apexification and periapical surgery followed by retrograde filling.[11] Ca(OH)2 (calcium hydroxide) is mostly used for the procedure but MTA has come up as an alternative material of choice for apexification because of more chances of success than that of Ca(OH)2apexification as it forms better apical barrier.[12] Other reason is that use of calcium hydroxide paste inside the canal for a longer period can make dentinal walls of root weak. But the same risk of root splitting remains with MTA based apexification as well as there is no new formation of root dentine but just an apical barrier.[16,17]

A new concept has come in recent years to treat cases of non-vital teeth with immature apices i.e regenerative endodontics.[13,14] Regenerative approaches is based on concept that vital tissue can be formed inside canal of non-vital tooth with revasularization procedure which will allow continued growth of root length and thickness. The reason behind this is that if any of DPSC and SCAP15 has survived, they can be used in the complete formation of root.[16-18] Stem cells are usually inactive in vivo and may get activated by micro environmental changes such as tissue injury or disease.[19-24] In cases of immature non vital teeth, there is always a chance that some remenants of vital pulpal tissue may have survived in periapical region which can be used for tissue generation. The regenerative procedure in non-vital teeth with open apices can be considered successful if there is healing of periapical defect and increase root wall thickness and length with subsequent closure of apices.

Revascularization:

In a normal development of teeth apexogenesis occurs with complete formation of teeth. But in incompletely formed nonvital teeth treated with apexification there is development of only a hard calcific barrier at root apex where as in case of same teeth treated with revascularization procedure there is complete formation of root. If Hertwig Epithelial Root Sheath cells have survived in non-vital teeth than after revascularization procedure they can message stem cells (PDLSCs) to transform into cells resembling like cementoblasts and produce tissue resembling cementum to continue root development.[27,28] They can also message apical papilla cells to transforms into odontoblasts like cells and help in formation of tissue resembling root dentine leading to increase in thickness and length walls. In revascularization procedure minimal or no mechanical instrumentation is done inside canal to preserve integrity of remaining dentinal walls and only copious irrigation and an antibiotic paste or calcium hydroxide paste for disinfection is used. After the root canal disinfection, overinstrumentation was done to start bleeding in peri-apical area and blood is allowed to clot inside canal. This clot is believed to serve as a scaffold to hold stem cells required for completion of root apex and for their differentiation. In study, out of 35 patients on whom revascularization procedure was done only 11 [Table 2] showed some response to electric pulp test after 03 months indicating that some sort of sensory tissue might have occurred after revascularization procedure. But after 06 months only one patient out of eleven showed positive response to pulp sensibility test indicating that false positive result may have occurred at the end of 03 month. After 09 months only one patient showed positive response to electric pulp test, indicating that some innervation or pulp tissue has been regenerated in the canal. However the true nature of this tissue can only be confirmed by histopathological analysis.[28]

All the 11 patients which were continued in study showed positive response to development of root at the end of 09 months indicating that stem cell of apical papilla and HERS may have survived after trauma in treated cases. No case showed complete closure of apex at the end of 09 months. This may be due to short follow up period but all cases showed positive response to treatment judging by the fact of disappearing symptoms and continued root development.

CONCLUSION

The results conclude that pulp regeneration procedure may be considered as a treatment option for patients with immature apices following trauma.

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How to cite this article: Chowdhry S, Verma M, Bedi BS, Rana R. Revascularization in Anterior Teeth with Immature Apices. Ann. Int. Med. Den. Res. 2019; 5(5):DE25-DE31.

Source of Support: Nil, **Conflict of Interest:** None declared