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Comparative evaluation of push-out bond strength of resin based endodontic sealer in fluorosed and non fluorosed teeth- An in vitro study

A.S Prasad[1], Ravi Vaiyapuri[2], Pushpalatha.K[3], Jambai Sampath Kumar Sivakumar[4], Saravana Priyan Soundappan[5], Chittrarasu Mathimaraiselvan[6]

[1](Reader)Department of Conservative Dentistry and Endodontics
Vivekanandha Dental College for Women, India
[2](Professor and Head of The Department) Conservative Dentistry and Endodontics
Vivekanandha Dental College for Women,India
[3](Post Graduate Student) Department of Conservative Dentistry and Endodontics
Vivekanandha Dental College for Women, India
[4](Reader) Department ofConservative Dentistry and Endodontics
Vivekanandha Dental College for Women, India
[5](Reader) Department of Conservative Dentistry and Endodontics
Vivekanandha Dental College for Women, India
[6](Senior Lecturer) Department of Conservative Dentistry and Endodontics
Vivekanandha Dental College for Women, India
Corresponding Author: Pushpalatha. K (Post Graduate Student)
Department of Conservative Dentistry and Endodontics

Abstract:
Aim: *To evaluate the push-out bond strength of resin based endodontic sealer in fluorosed and non fluorosed teeth.*
Materials and Methods: *Twenty extracted single rooted permanent teeth (Ten teeth affected with Fluorosis and Ten teeth not affected with Fluorosis) were collected. Access opening was done, pulp tissue was extirpated, working length was determined with 15 size K file, cleaning and shaping was done up to Protaper F3 under copious irrigation. The samples were divided into two groups each containing ten specimens (Group1 - Teeth affected with Fluorosis and Group 2 - Teeth not affected with Fluorosis). Obturation was done using single cone gutta percha coated with AH plus sealer, the access cavity was sealed with Cavit and was incubated at 37˚C at 100 % relative humidity for 2 weeks. After 2 weeks the samples were sectioned into three slices. The push-out bond strength of each specimen was calculated using Universal Testing Machine. The data obtained was statistically analyzed using One-way analysis of variance (ANOVA) and Student t- test.*
Results: *There was significant difference between the bond strength of teeth that were not affected with Fluorosis and the teeth affected with fluorosis. The bond strength of the teeth that was not affected with Fluorosis was higher as compared to the fluorosed teeth.*
Conclusion: *Push out bond strength values of AH Plus sealer were different in fluorosed and non fluorosed teeth and varied significantly in the Coronal, Middle and Apical third of the root canal.*
Key Word:*Dental Fluorosis, AH plus sealer, Push-out bond strength*

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I. Introduction

Successful root canal treatment depends on the thorough debridement of the root canal system, the elimination of pathogenic microorganisms and finally, the complete sealing of the canal space to prevent ingress of the bacteria from the oral environment and spread to the apical tissues [1].The American Association of Endodontist defines obturation as “a three-dimensional filling of the root canal system as close to the cementoenamel junction as possible [2]. The use of a solid core in conjunction with a sealer is the most frequently used method of obturation. In order to obtain a fluid tight or a fluid impervious seal a sealer should exhibit certain properties like insolubility, low shrinkage, bacteriostatic, hermetically sealing etc. Also, the bond strength of the root canal sealer is important for maintaining the integrity of the seal in the root canal filling. Therefore, sealers should also demonstrate adhesive properties to dentin. This adhesive property may lead to greater strength of the restored tooth and may provide greater resistance to tooth fracture thus, decreasing the chances of endodontic failure and increasing the clinical longevity of an endodontically treated tooth [3].Dental fluorosis results in hypo mineralization of tooth enamel caused by continuous ingestion of excessive amount of fluoride during tooth development [4]. Anti-cariogenic and positive effects of fluorides on teeth and carious lesions are proved in Dentistry. The enamel, however, is not the only component of teeth that is affected. Fluorosed teeth exhibit changes ranging from superficial enamel mottling to severe hypoplasia of the enamel and dentine[5].

Several studies have demonstrated, dental fluorosis can also impair the mineralization of dentin as well. As we live in the Fluorosed belt a pilot study was conducted by treating patients with badly decayed and infected fluorosed tooth by root canal treatment and post and core. Numerous studies have been done on the bond strength of various endodontic sealers in normal teeth; Very few or no studies have been done on the intra radicular surface of the teeth affected with fluorosis. The push-out test is commonly used to evaluate bond strength between sealer and root dentin. This test provides a better evaluation of bond strength because here fracture occurs parallel to the resin interface [6]. Thus, the purpose of this pilot study was to compare the bond strength of a resin based endodontic sealer in fluorosed and non fluorosed teeth.

II. Materials and Methods

Sample selection and preparation

Twenty human maxillary anterior teeth (Ten teeth affected with Fluorosis and Ten teeth not affected with Fluorosis) extracted for periodontal reasons were collected. Teeth were cleansed using ultrasonic scaler and disinfected by immersing in 2.5% sodium hypochlorite solution for 2hrs and stored in normal saline.

Root canal preparation:

The prepared specimens were divided into two groups namely
Group 1: Teeth not affected with Fluorosis
Group 2: Teeth affected with Fluorosis

The crowns were cut off below the cementoenamel junction using diamond disk (Buehler, Lake Bluff, NY) under copious water spray to a standardized root length of 15 mm. Working length was established by Ingle′s radiographic method. Further root canal preparation was done using ProTaper rotary instruments (Dentsply Maillefer) up to size F3 (size 30 .06 taper). At every instrument change, the canals were irrigated with 1ml of 2.5% sodium hypochlorite solution and finally irrigated with distilled water. After chemo mechanical preparation, the specimens were dried using sterile absorbent paper points. The root canals were obturated using F3 Gutta percha coated with AH plus sealer. After root filling, the access cavity was sealed with Cavit and the specimens were stored at 100% relative humidity at 37°C for a period of 2 weeks.

Push-out assessment:

After two weeks, each specimen was sectioned perpendicular to the longitudinal axis of the root under water coolant spray with a low-speed diamond saw (Minitom, Struer, Denmark). Three slices of 2 mm thickness were obtained from each root along the apical, middle, and coronal third regions.

The push-out test was performed on each specimen with a universal testing machine at a crosshead speed of 1mm/min. The diameter of the plunger used was approximately (at least) 80% diameter of the canal. The maximum load applied to the filling material before failure was recorded in Newtons and then converted to megapascals (MPa) according to the following formula.

$$\text{Push-out bond strength (MPa)} = \frac{\text{Maximum load (N)}}{\text{Adhesion area of root filling (A) (mm}^2\text{)}}$$

The adhesion area of the root canal filling was calculated using the following equation:
$A = (2\pi r) \times h$, r = radius of the intraradicular space, h represents the thickness of the root section (mm), and π is the constant 3.14.

III.Result

The mean push-out bond strength values were highest in the apical third followed by the middle third and least in the coronal thirds in both Group 1 and Group 2 (Table1). It was observed that the push-out bond strength values in Group 1 (Non-fluorosed teeth) was better than Group 2 (Fluorosed teeth) (Table 2).

Table 1: The mean push-out strength of each group in coronal, middle, and apical-third in MPa

S.No.	Group1 Non Fluorosed Teeth			Group2 Fluorosed Teeth		
	Coronal	**Middle**	**Apical**	**Coronal**	**Middle**	**Apical**
1	3.24	3.35	4.97	2.62	2.75	4.03
2	1.61	3.32	4.75	1.34	2.79	4.08
3	1.34	3.53	3.82	1.14	3.00	3.17
4	2.89	3.51	3.74	2.51	3.05	3.26
5	1.46	3.37	4.58	1.24	2.86	3.89
6	1.45	1.71	4.54	1.29	1.52	3.98
7	2.11	3.29	6.31	1.75	2.73	5.30
8	1.74	2.61	3.81	1.48	2.22	3.27
9	1.43	2.24	4.29	1.24	1.95	3.65
10	2.34	2.24	2.98	1.87	1.88	2.50

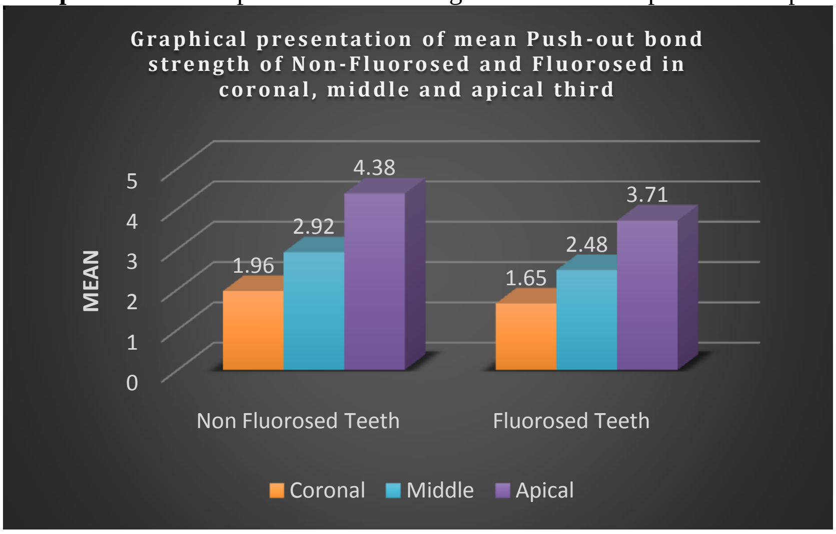
Table 2: One-way Analysis of Variance (ANOVA) of Group 1 and Group 2 in the coronal, middle and the apical thirds

Position	N	Push-out bond strength							
		Group 1				**Group 2**			
		Min	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**
Coronal	10	1.34	3.24	1.96	0.67	1.14	2.62	1.65	0.54
Middle	10	1.71	3.53	2.92	0.66	1.52	3.05	2.48	0.54
Apical	10	2.98	6.31	4.38	0.90	2.50	5.30	3.71	0.75

Table 3: Student -t test for comparison between the groups

		Push-out bond strength			
		Group 1	**Group 2**	**T**	**P**
Coronal	**Mean**	1.96	1.65	1.16	0.263
	SD	0.67	0.54		
Middle	**Mean**	2.92	2.48	1.65	0.117
	SD	0.66	0.54		
Apical	**Mean**	4.38	3.71	1.80	0.089
	SD	0.90	0.75		

Graph 1: The mean push-out bond strength values of Group 1 and Group 2



The mean push-out bond strength values were highest in the apical third followed by the middle third and least in the coronal thirds in both Group 1 and Group 2 (Table1). It was observed that the push-out bond strength values in Group 1 (Non-fluorosed teeth) was better than Group 2 (Fluorosed teeth) (Table 2).

III. Discussion

Dental Fluorosis is caused by excess fluoride ingestion mainly through drinking water. Dental fluorosis is prevalent in many districts of Tamilnadu especially in the southern part. Fluorosis is known to be an endemic disease that affects both the dental tissue and skeletal system. In this pilot study, SEM analysis was not done to evaluate the samples and the Fluorosis teeth were selected according to the Dean's Fluorosis index Score- 3: Mild, opaque white areas covering less than 50% of the tooth surface. Therefore, it is clinically important for us to understand the characteristic changes of dentin in the fluorosed teeth and the bonding ability of root canal sealers to radicular dentin in fluorosed teeth.

Fluoride has a high affinity for calcified tissues and is concentrated in dental and bone structures [7]. At elevated concentrations, fluoride disturbs the mineralization process [8] (usually 2 to 8 ppm) during the period of tooth development. Fluorosis affects the enamel, characterized by an outer hypermineralized layer and subsurface hypomineralized enamel composed of sparsely arranged large crystallites and a few small crystallites [9].

The studies have shown that the fluorosis also affects the dentin, which involves both the organic and inorganic components. Biological apatite minerals in normal human dentine are reported to be in the form of calcium deficient and carbonate-rich hydroxyapatite. In a study it was speculated that fluorosed dentine might be made of apatite that is much more towards carbonated apatite rather than the normal dentine and not pure hydroxy apatite or fluorohydroxy apatite which are less soluble in acid [10]. Moderately and severely fluorosed teeth showed hypomineralization of dentin and increased interglobular dentin. [11]

A positive correlation has been observed between dental fluorosis severity and the dentine fluoride concentration [12].

In the present study AH plus, an epoxy resin-based sealer is used. This sealer is commonly used as the gold standard for comparison with the other root canal sealers. Adhesion of an endodontic sealer is defined as its capacity to adhere to the root canal walls and promote the union of gutta-percha cones to each other and to the dentin [13].

To test the bond strength, push-out test is more reliable than other tests, and the push-out method better reflects the clinical status of the fracture to determine the bond strength of root canal sealer. This test has been used by many researchers to determine the bond strength [14]. The push-out test design has several advantages over the other tests. This test design makes it easy to align samples for testing and is less sensitive to small variations among specimens and to the variations in stress distribution during load application. The model has been shown to be effective and reproducible and this method allows root canal sealers to be evaluated even when bond strengths are low [15].

In the current study it was observed that the push-out bond strength values were significantly higher in the apical third region followed by the middle third and least in the coronal thirds with significant difference between fluorosed teeth and non-fluorosed teeth. The results are in accordance with the previous studies reporting higher bond strengths to dentin in apical one third [16,17,18]. Sagsen et al reported higher bond strength values at the middle and apical thirds, and this result possibly may be related with the forces applied during root canal filling [19]. Such force increases the frictional strength of the sealer against the root canal walls, and consequently, contributes to the adhesion of the sealer to dentin substrate [20].

However, the bond strength of AH plus sealer is reduced in the fluorosed teeth compared to the non-fluorosed teeth which might be due to distinct changes in mineralization pattern of fluorotic dentine that exhibits accentuated incremental growth patterns, variation of mineral content in dentine with occasional bands of interglobular dentine , deviated morphology and arrangement of apatite crystallites and collagen fibrils of fluorosed dentin[21,22]. Causton (1984) demonstrated that calcium level is an important factor in determining bond strength, where there was lower degree of mineralization in the deep dentine surface than those of the upper dentine [23]. Perdigao et al. (2001) stated that dentine adhesion depends on the presence of calcium in the bonding area [24]. This might be the cause for the decrease in the bond strength of the fluorosed teeth.

Hence, further studies have to be done to improve the methods of bonding to radicular dentin in fluorosed teeth.

IV. Conclusion

Within the limitations of the present study, push out bond strength of AH plus sealer were significantly different in fluorosed and non fluorosed teeth with maximum interfacial bond at the apical third than the Coronal and Middle third of the root canal.

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