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Comparative evaluation of dentin bond strength of Epoxy resin based sealer, MTA based sealer and Gutta Flow 2: An *in vitro* study

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Abstract
Sealer cements are an essential component of root-filling materials to fill any voids and gaps between the main root-filling material and root dentin. Good adhesion to tooth material within the root canal is one of the ideal properties of a sealer cement, which potentially influences both leakage and root strength. Increased adhesive properties to dentin may lead to greater strength of the restored tooth, which may provide greater resistance to tooth fracture and clinical longevity of an endodontically treated tooth. The present study was to compare the push-out bond strength of 3 different root canal sealers. Forty-five extracted human single-rooted teeth were selected and decoronated below the cement enamel junction so that all the roots were 12 mm in length. The working length was determined and the cervical portion of the canals was prepared by using #2 and #3 Gates-Glidden drills. The root canals were instrumented by means of the step-back technique to a size 40 K-Flexofile (Dentsply). There was a significant difference between all the 3 groups with AH plus sealer group (group A) showing stastically significantly higher bond strength at all the three levels when compared with MTA Fillapex and GuttaFlow 2 group. Significant difference was also observed between MTA Fillapex group (group B) and GuttaFlow 2 (group C) with higher bond strength values for MTA Fillapex when compared with GuttaFlow 2 which has least bond strength values. MTA Fillapex showed lower bond strength when compared to that of AH plus sealer, MTA Fillapex presented acceptable resistance to dislodgement, similar to that observed in samples filled with an epoxy-based root canal sealer and it is more biocompatible and can be recommended for use with further investigations of other features of this root canal sealer.

Keywords: Root canal sealers, push-out bond strength, fillapex, dentin

Introduction
Successful root canal treatment depends on thorough debridement of the root canal system, the elimination of pathogenic organisms and finally the complete sealing of the canal space to prevent ingress of bacteria from the oral environment and spread to the periapical tissue [1]. Therefore successful root canal therapy requires a complete obturation of the root canal system with non-irritant biomaterials. It is known that the majority of endodontic failures have been caused by the incomplete sealing of root canal and restorative shortcomings, confirming the necessity of using materials capable of forming a fluid impervious seal between the root canal system and the peri-radicular tissues. Strength of the bond of root canal sealers to gutta-percha and dentin seems to be the important property for maintaining the integrity of apical seal, and obtaining a fluid impervious seal, along with cleaning and shaping the root canal, one of the keys to achieve a long-term successful endodontic treatment [2]. Gutta-percha is the most commonly used core filling material for endodontic obturation. Although it is not the ideal filling material, it has been used in conjunction with a sealer as the material of choice for over 100 years [3]. The use of a root canal sealer in conjunction with a core material remains the most widely accepted obturation technique in endodontics. An adequate seal cannot be obtained without the use of a sealer because gutta-percha does not spontaneously bond to dentin walls. Therefore, ideal endodontic cement should show good sealing ability. In addition, it should have adhesive strength and also have cohesive strength to hold the obturation together [4].

It is desirable for the sealer to adhere firmly to both root canal wall and the core material, which might improve the sealing ability via the elimination of fluid-permeable spaces and contribute to the stability of the filling, during mechanical stress (post space preparation).

Aim of the study
To evaluate the push out bond strength of MTA-based sealer (MTA Fillapex), Epoxy resin based sealer (AH plus sealer) and GuttaFlow 2 (which is a combination of sealer and gutta percha) between root canal dentin and gutta-percha at three different levels.

Materials and Methods
Forty-five extracted human single-rooted teeth were selected, disinfected by removing the hard deposits using curettes and soft deposits by soaking in 5.25% Sodium hypochlorite (NaOCl)for 30 minutes and autoclaved and stored in distilled water. These 45 teeth were decoronated below the cementoenamel junction so that all the roots were 12 mm in length. To standardize the working length, a size 10 K-file (Dentsply) was inserted into the root canal until the tip of the file could be visualized at the apical foramen. The working length was determined by subtracting 1 mm from this length. The cervical portion of the canals was prepared using #2 and #3 Gates-Glidden drills. Then the root canals were instrumented by means of the step-back technique to a size 40 K-Flexofile (Dentsply). Irrigation was done with 1 mL of 3% sodium hypochlorite preceding the use of each instrument. Finally, the canals were rinsed with sterile saline, and dried with absorbent paper points**.** The adopted technique allowed the standardization of the cervical diameter and apical enlargement (upto a #40 endodontic file) of the canals. The 45 roots were randomly assigned to 3 groups of 15 teeth each for obturation with different sealers.

Group 1: An ISO standardized 40 size gutta-percha cone that matched the master apical file was fitted to the working length with tug back. AH Plus sealer was mixed according to the manufacturer's instructions. The sealer was placed into the canal using lentulospiral and the master cone was coated with AH Plus and placed into the canal. Lateral condensation was then carried out using accessory gutta-percha cones. The gutta-percha cones coated with sealer were laterally compacted until they could not be introduced more than 3 mm into the root canal. Excess gutta-percha was removed with a heated instrument.

Group 2: An ISO standardized 40 size gutta-percha cone that matched the master apical file was fitted to the working length with tug back. MTA Fillapex sealer was mixed according to the manufacturer's instructions. The sealer was placed into the canal using lentulospiral and the master cone was coated with sealer and placed into the canal. Lateral condensation was then carried out using accessory gutta-percha cones. The gutta-percha cones coated with sealer were laterally compacted until they could not be introduced more than 3 mm into the root canal. Excess gutta-percha was removed with a heated instrument.

Group 3: A 40 size gutta-percha cone that matched the master apical file was fitted to the working length with tug back. Gutta flow 2 was mixed according to the manufacturer's instructions. The sealer was placed into the canal using lentulospiral and the master cone was coated with Gutta flow 2 and placed into the canal without lateral condensation. Excess Gutta Percha sheared off with a heated instrument.
On completion of these procedures, the specimens were radiographically examined to check the presence of voids. After 7 days, the roots stored in distilled water and then sectioned perpendicularly to the long axis of the tooth into 1 mm thick slices by using water cooling and slow speed straight hand piece with diamond disc. Three slices of each root were stored in distilled water for 24 hours, and then the push-out test was performed. The cervical and apical diameters of the canal and the thickness of all the slices were measured with a digital caliper. Each section was marked on its apical side and positioned on a base, with a central hole, in a universal testing machine for the push-out test. A compressive load to the apical side of each slice was performed by using a 0.35mm diameter cylindrical plunger attached to the upper portion of the testing machine. A crosshead speed of 1mm/min was applied until bond failure occurred. The maximum load at failure was recorded in newtons (N) and the bonding surface (A) was calculated using the equation.

$$A=2\,\pi r \times h$$

Where π is the constant 3.14, r is the root canal space radius, and *h* is the thickness of the slice in mm. Then the bond strength (δ), expressed in MPa was calculated using the equation.

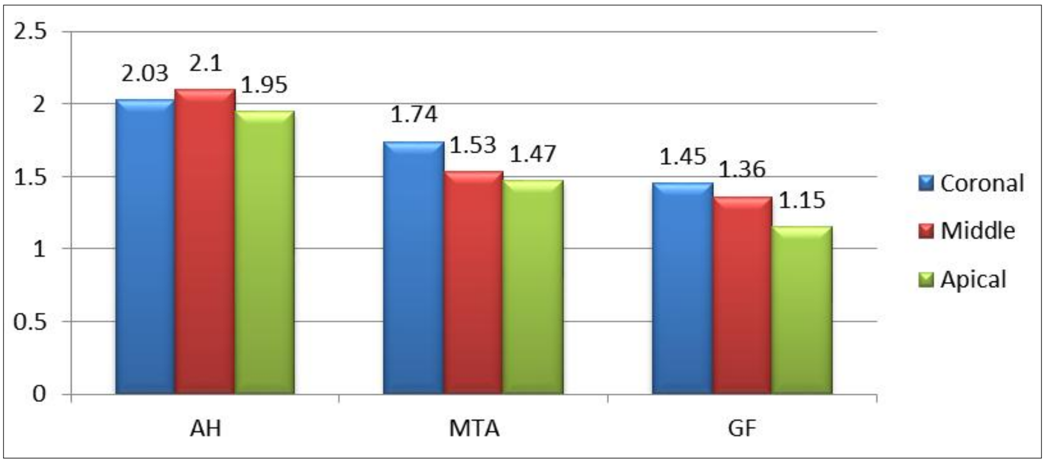
$$\delta(\text{MPa}) = \frac{F}{A}$$

Results
All the analysis was done using SPSS version 14. A p-value of <0.05 was considered statistically significant. The comparison of mean bond strength using ANOVA with post-hoc Games Howell test and Tukey's test.

Table 1: Intra-group comparison of each site.

Group	Site						p-value	Post-hoc test
	Coronal		Middle		Apical			
	Mean	SD	Mean	SD	Mean	SD		
AH‡	2.03	.15	2.10	.14	1.95	.10	<0.018; Sig	Middle>Coronal>apical
MTA†	1.74	.21	1.53	.17	1.47	.13	<0.001; Sig	Coronal >Middle> apical
GF‡	1.45	.10	1.36	.08	1.15	.13	<0.001; Sig	Coronal>Middle>apical

†ANOVA with post-hoc Games Howell test
‡ANOVA with post-hoc Tukey's test

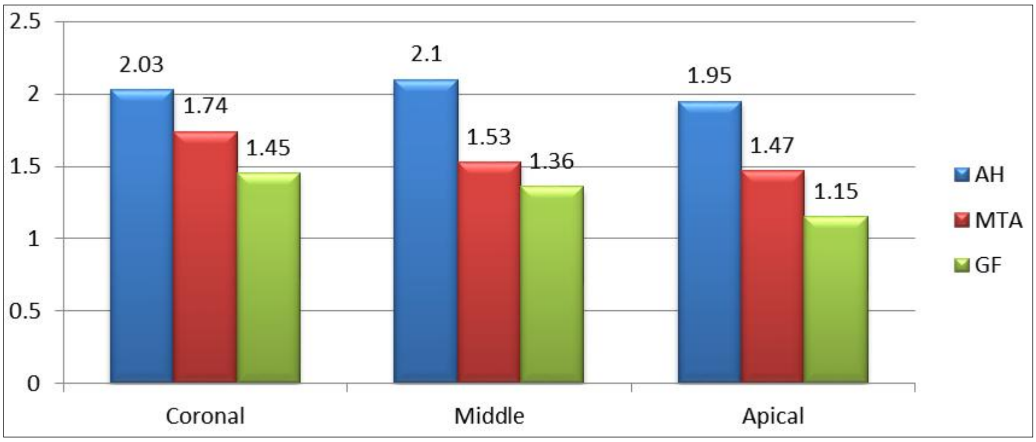


Graph 1: Showing Means of Coronal, Middle and Apical sites of AH, MTA and GF- Intra Group Comparison

Table 2: Inter-group comparison at each site

Group	Site						p-value	Post-hoc test
	AH		MTA		GF			
	Mean	SD	Mean	SD	Mean	SD		
Coronal†	2.03	.15	1.74	.21	1.45	.10	<0.001; Sig	AH>MTA>GF
Middle†	2.10	.14	1.53	.17	1.36	.08	<0.001; Sig	AH>MTA>GF
Apical‡	1.95	.10	1.47	.13	1.15	.13	<0.001; Sig	AH>MTA>GF

†ANOVA with post-hoc Games Howell test
‡ANOVA with post-hoc Tukey's test



Graph 2: Showing Means of Coronal, Middle and Apical sites of AH, MTA and GF- Inter Group Comparison

Results

There was a significant difference between all the 3 groups with AH plus sealer group (group A) showing stastically significant higher bond strength at all the three levels when compared with MTA Fillapex and GuttaFlow 2 group. Significant difference was also observed between MTA Fillapex group (group B) and GuttaFlow 2 (group C) with higher bond strength values for MTA Fillapex when compared with GuttaFlow 2 which has least bond strength values. Within the groups the coronal portion showed higher bond strength when compared with middle and apical portion for MTA Fillapex and GuttaFlow 2 but middle portion showed slightly higher bond strength compared with coronal portion and apical portion for AH plus sealer group.

Table 3: Maximum force, Area and bond strength of AH Plus sealer

Sample	Coronal			Middle			Apical		
	Max. force (N)	Area (mm^2)	Bond strength (MPa)	Max. force (N)	Area (mm^2)	Bond strength (MPa)	Max. force (N)	Area (mm^2)	Bond strength (MPa)
1	8.414	4.145	2.03	5.839	2.794	2.09	2.908	1.507	1.93
2	7.028	3.862	1.82	5.485	2.857	1.92	3.533	1.758	2.01
3	7.693	3.925	1.96	5.462	2.417	2.26	3.028	1.664	1.82
4	9.935	5.710	1.74	6.482	2.920	2.22	3.305	1.695	1.95
5	7.283	3.485	2.09	4.653	2.449	1.90	3.623	1.821	1.99
6	9.191	3.862	2.38	5.075	2.417	2.10	2.978	1.664	1.79
7	9.917	5.086	1.95	5.643	2.700	2.09	2.983	1.538	1.94
8	11.016	5.400	2.04	5.990	2.951	2.03	2.628	1.444	1.82
9	11.024	5.275	2.09	5.707	2.606	2.19	3.250	1.601	2.03
10	9.723	4.961	1.96	5.352	2.731	1.96	3.051	1.632	1.87

11	9.805	4.647	2.11	5.961	2.951	2.02	3.709	1.758	2.11
12	10.116	4.772	2.12	4.983	2.637	1.89	3.574	1.727	2.07
13	10.007	5.212	1.92	5.878	2.512	2.34	3.478	1.821	1.91
14	12.003	5.557	2.16	5.953	2.731	2.18	3.384	1.727	1.96
15	10.432	4.898	2.13	5.534	2.449	2.26	3.461	1.664	2.08

Bond strength $\delta(MPa) = \frac{F}{A}$

Table 4: Maximum force, Area and bond strength of MTA Fillapex sealer

Sample	Coronal			Middle			Apical		
	Max. force (N)	Area (mm^2)	Bond strength (MPa)	Max. force (N)	Area (mm^2)	Bond strength (MPa)	Max. force (N)	Area (mm^2)	Bond strength (MPa)
1	9.948	5.589	1.78	4.730	2.920	1.62	2.986	1.821	1.64
2	8.236	4.992	1.65	4.934	2.731	1.69	2.405	1.683	1.43
3	9.485	5.212	1.82	4.671	2.700	1.73	2.661	1.695	1.57
4	8.802	5.400	1.63	4.029	2.920	1.38	1.899	1.557	1.22
5	8.960	4.458	2.01	3.117	2.417	1.29	2.373	1.840	1.29
6	7.569	3.862	1.96	3.089	2.323	1.33	2.296	1.664	1.38
7	9.510	5.086	1.87	3.761	2.559	1.47	2.122	1.444	1.47
8	10.422	5.400	1.93	2.830	2.229	1.27	2.315	1.485	1.56
9	9.336	5.275	1.77	3.701	2.373	1.56	2.413	1.620	1.49
10	7.639	4.961	1.54	4.019	2.716	1.48	2.526	1.673	1.51
11	6.645	4.647	1.43	5.145	2.957	1.74	2.781	1.783	1.56
12	7.110	4.772	1.49	4.435	2.656	1.67	2.823	1.742	1.62
13	7.248	5.212	1.39	4.068	2.559	1.59	2.274	1.777	1.28
14	10.565	5.620	1.88	3.708	2.687	1.38	2.573	1.727	1.49
15	10.031	5.118	1.96	4.597	2.612	1.76	2.694	1.833	1.47

Table 5: Maximum force, Area and bond strength of GuttaFlow 2

Sample	Coronal			Middle			Apical		
	Max. force (N)	Area (mm^2)	Bond strength (MPa)	Max. force (N)	Area (mm^2)	Bond strength (MPa)	Max. force (N)	Area (mm^2)	Bond strength (MPa)
1	7.279	5.275	1.38	3.827	2.794	1.37	2.023	1.632	1.24
2	7.420	4.882	1.52	3.822	2.750	1.39	2.036	1.711	1.19
3	6.814	5.124	1.33	3.544	2.411	1.47	2.124	1.673	1.27
4	7.846	5.338	1.47	3.685	2.857	1.29	2.070	1.557	1.33
5	6.318	4.898	1.29	3.300	2.292	1.44	2.152	1.840	1.17
6	6.138	4.176	1.47	2.902	2.182	1.33	1.655	1.639	1.01
7	6.523	5.137	1.27	3.275	2.559	1.28	1.850	1.381	1.34
8	8.247	5.426	1.52	3.057	2.248	1.36	1.769	1.450	1.22
9	7.840	5.262	1.49	3.307	2.625	1.26	1.882	1.651	1.14
10	6.822	4.980	1.37	3.263	2.386	1.37	1.627	1.535	1.06
11	6.895	4.659	1.48	3.636	2.863	1.27	1.759	1.708	1.03
12	7.266	4.458	1.63	4.202	2.694	1.56	1.713	1.767	0.97
13	8.676	5.457	1.59	3.481	2.505	1.39	1.922	1.576	1.22
14	7.796	5.268	1.48	3.654	2.687	1.36	1.572	1.557	1.01
15	7.767	5.432	1.43	2.883	2.201	1.31	1.488	1.519	0.98

Discussion
Complete filling of the prepared root canal system is an important component of successful root canal treatment. The function of root canal filling is to seal the root canal system to prevent microorganisms and/or their toxic products reaching the periodontal tissues [5].

Accomplishment of ideal root canal treatment is attributed to various essential factors such as proper instrumentation, biomechanical preparation, obturation, and ultimately depending upon the case, post-endodontic restoration. The pertinent aim of this treatment is to do away with the microbial entity and any future predilection of re-infection. In order to achieve this, proper seal is required to denigrate any chance of proliferation of bacteria and future occurrence of any pathology. Sealer along with solid obturating material acts synergistically to create hermetic seal [6].

The main components of MTA are tricalcium oxide, tricalcium silicate, bismuth oxide, tricalcium aluminate, tricalcium oxide, tetracalcium aluminoferrite and silicate oxide and other mineral oxides. Because calcium silicate cements set in the presence of moisture, such as blood and other fluids with a great clinical advantage it appeared interesting to develop endodontic sealers based on calcium silicate hydraulic cements [7].

MTA Fillapex is new salicylate resin and calcium silicate-based sealer. It contains calcium silicate, salicylate resin, diluting resins, natural resin, nan-oparticulated resin and bismuth trioxide. According to the author Sarkar *et al*. it is anticipated that release of calcium and hydroxyl ions from the set sealer will result in the formation of apatites when the material comes into contact with phosphate-containing fluids [8]. MTA Fillapex is first paste: paste MTA based salicylate resin root canal sealer, versatile for every obturation method. It delivers easily and without waste and exhibits excellent handling properties with an efficient setting time.

Half of MTA Fillapex paste: paste formula contains 13.2 % MTA.MTA known for its biocompatibility, yields an impressive, hermetic seal in which the MTA particles expand, prevent micro-infiltration, the other contains biologically compatible salicylate resin which is tissue friendly and therefore a better choice over epoxy based resins, which have been shown to have mutagenic and more cytotoxic effects. MTA Fillapex two pastes combine in a homogenous mix to form a rigid, but semipermeable structure with excess MTA dispersed throughout. The MTA activity is possible because of its permeability [7].

MTA Fillapex (Group 2) had lowest bond strength to root dentine when compared to AH Plus sealer. Sarkar *et al* suggested that release of calcium and hydroxyl ions from the set sealer will result in the formation of apatites as the material comes into contact with phosphate-containing fluids [8]. Reyes-Carmona *et al* reported that the apatite formed by MTA and phosphate-buffered saline was deposited within collagen fibrils, promoting controlled mineral nucleation on dentine, seen as the formation of an interfacial layer with tag-like structures. The reason for the low bond strength of MTA Fillapex in the present study could be the low adhesion capacity of these tag-like structures [8].

Since MTA Fillapex is mainly composed of a combination of resins, silica, and MTA, Similarities related to resin-based sealers and some differences on the physical properties of the original MTA formulation are expected for MTA Fillapex, in spite of its favorable biological features and ability to release calcium ions. Thus, the similarities between MTA Fillapex and AH Plus regarding bond strength, pattern of failure, and handling characteristics are also corroborated by the sealers' composition. Regardless of the lower bond strength compared with AH Plus sealer, the similarities related to AH plus revealed that MTA Fillapex presents acceptable values on the push-out test. Accordingly, AH Plus can be considered the gold standard material for testing endodontic sealers resistance to dislodgment, because previous studies have pointed out that it presents advantages in comparison with other materials usually used. On the basis of the present results and previous studies, MTA Fillapex has the potential to capitalize on the biological and sealing characteristics of MTA and, at the same time, improve its flow rate and manipulation characteristics. Further studies are warranted to clarify other physical properties of this new material [9].

Previous works reported higher adhesiveness to root dentin in AH Plus sealer group than in MTA Fillapex group which are similar to the present study. Ricardo Abreu da Rosa *et al*. conducted a study to evaluate the influence of various endodontic sealers composition and the time of fiber post cementation after root filling on the post adhesion to bovine root dentin. They concluded that no significant difference in bond strength were observed when post was cemented immediately and after 15 days except that after 15 days the epoxy resin-based sealer had higher bond strength values than salicylate resin based and eugenol-based sealers [10].

Sagsen *et al* evaluated the bond strength of 2 new calcium silicate–based and AH Plus endodontic sealers and found that MTA Fillapex had lower push‑ out bond values than the AH Plus sealer [11].

Marina Samara Baechtold stated that when exposed to scanning electronic microscopy, AH plus exhibited longer and uniform *tags*, showing its higher mechanical imbrication and resulting in greater bonding capacity, while MTA Fillapex cement displayed little or none formation of tags [12].

GuttaFlow 2 is a cold flowable filling system for root canals, combining sealer and gutta-percha in one product. GuttaFlow 2 is a novel filling system for root canals that combines two products in one: gutta-percha in powder form with a particle size of less than 30 µm, and sealer. This new filling system works with cold free-flow gutta-percha. It consist of Polydimethyl polymethyl hydrogen siloxane, Silicone oil, Paraffin oil, Zirconium dioxide, Platin catalyst, Guttapercha, Zinc oxide, Barium sulfate and micro silver.

Gutta Flow-2 sealer is an alternative root filling material introduced newely into the endodontic practice. GuttaFlow-2 is a cold flowable filling system for root canals, combining sealer and gutta-percha in one product. GuttaFlow-2 group showed a significant difference with least bond strength when compared to AH Plus group and MTA Fillapex group. According to Tummala *et al*. the wettability of the root canal sealers influences its adaptability to the radicular dentin. AH Plus sealer was shown to wet the root dentin surface better than the GuttaFlow sealer and this could be attributed to its ability to penetrate into the micro-irregularities better. GuttaFlow showed poor wetting on the root dentin surface because of the presence of silicone, which possibly produces high surface tension forces, making the spreading of these materials less [1].

T Sagsen *et al*. Conducted a study to evaluate the push-out bond strength of AH Plus sealer, I Root SP sealer and MTA Fillapex and they concluded that higher bond strengths in the middle and apical specimens for AH Plus sealer and I Root SP than MTA Fillapex sealer could be related to deeper sealer penetration because of higher lateral condensation forces or as a result of the dentine structure in these parts of the roots but no significant difference in the coronal region [8].

AH Plus sealer/guttapercha had highest bond strength at all the three levels when compared to that of MTA Fillapex /gutta-percha and Gutta Flow2/guttapercha. The middle portion of MTA Fillapex showed higher bond strength values when compared to that of coronal and apical third region which were in agreement with the previous studies. This is because, the tubular density of the pulpal coronal dentin was significantly greater than that of radicular dentin (middle and apical third region).

From a practical standpoint, close examination of the present results yields an interesting thought for further consideration; despite the theoretical development reached by the introduction of current dentin adhesive technology to be used for root-filling procedures, the simple and cost-effective nonbonding root fillings are still the more reliable choice [13].

Adhesive strength is only one aspect of root canal sealers. Further investigation of various aspects of root canal sealers is necessary. Which sealers seal better in the presence, as well as the absence, of smear layer is one specific area that needs further evaluation. In addition, studies are needed regarding which sealer works best in specific situations such as open apices, apical deltas, ledged canals, and with specific obturation technique [2].

The present results cannot be used to estimate leakage. According to Orstavik *et al*, tensile bond strength might not reflect homogeneous adaptation of the material to the dentin and gutta-percha surfaces, because points of contact causing adhesion might be interspersed with voids allowing leakage [9].

Conclusion

Adhesive strength is only one aspect of the quality of root canal sealing, but it may be considered one of the most important feature of root canal sealer. Although MTA Fillapex showed lower bond strength when compared to that of AH plus sealer, MTA Fillapex presented acceptable resistance to dislodgement, similar to that observed in samples filled with an epoxy-based root canal sealer and it is more biocompatible and can be recommended for use with further investigations of other features of this root canal sealer.

Limitations of the study
The present evaluation examined only one aspect of the question of which sealer is best in terms of adhesion to dentin and gutta-percha. Further in *vivo* and in *vitro investigations* are recommended for a conclusive report on newer resin-based sealers.

References

1. Sundus Naser H, Iman Al-Zaka M. Push-out bond strength of different root canal obturation Materials. J Bagh Coll Dentistry. 2013; 25(1):14-20.
2. Shibu Thomas Mathew, Mithra Hegde N. Shear bond strength of eugenol- and non-eugenol–based endodontic sealers to gutta-percha and dentin: An *in vitro* study. J Conserv Dent. 2008; 11(1):30-36.
3. Marilia Sly M, Keith Moore B, Jeffrey Platt A, Cecil Brown E. Push-Out Bond Strength of a New Endodontic Obturation System (Resilon/Epiphany). J Endod. 2007; 33:160-162.
4. Seyda Ersahan, Cumhur Aydin. Dislocation Resistance of iRoot SP, a Calcium Silicate–based Sealer, from Radicular Dentine. J Endod. 2010; 36:2000-2002.
5. Resende LM, Rached-Junior MA, Versiani AE, Souza CES, Miranda YTC, Silva-Souza. A comparative study of physicochemical properties of AH Plus, Epiphany, and Epiphany SE root canal sealers. IEJ. 2009; 42:785-793.
6. Sanjeev Tyagi, Priyesh Mishra, Parimala Tyagi. Evolution of root canal sealers: An insight story. European Journal of General Dentistry. 2013; 2(3):199-218.
7. Manjula Rawtiya, Kavita Verma, Shweta Singh, Swapna Munaga, Sheeba Khan. MTA based root canal sealers. Journal of orofacial research. 2013; 3(1):16-21.
8. Sagsen Ustun, Demirbuga, Pala K. Push-out bond strength of two new calcium silicate -based endodontic sealers to root canal dentine. International Endodontic Journal. 2011; 44:1088-1091.
9. Eloisa Assmann, Roberta Kochenborger Scarparo, Daiana Elisabeth Bottcher, Fabiana Soares Grecca. Dentin Bond Strength of Two Mineral Trioxide Aggregate–based and One Epoxy Resin–based Sealers. J Endod. 2012; 38:219-221.
10. Ebru Ozsezer, Safak Kulunk, Gozde Yuksel, Duygu Sarac, Bilinc Bulucu. Effect of three canal sealers on bond strength of a fibre post. JOE. 2012; 36(3):497-501.
11. Evren OK, Huseyin Ertas, Gokhan Saygili, Tuba Gok. Effect of photoactivated disinfection on bond strength of three different root canal sealers. European Journal of Dentistry. 2014, 8(1).
12. Marina Samara Baechtold, Ana Flávia Mazaro, Bruno Monguilott Crozeta, Denise Piotto Leonardi, Flavia Sens Fagundes Tomazinho, Flares Baratto-Filho *et al*. Adhesion and formation of tags from MTA Fillapex compared with AH Plus cement. RSBO. 2014; 11(1):71-76.
13. Gustavo De-Deus, Karina Di Giorgi, Sandra Fidel, Rivail Antonio Sergio Fidel, Sidnei Paciornik. Pushout bond strength of resilon/epiphany and resilon/epiphany SE to root dentin. JOE. 2009; 35:1048-1050.