Effect of Different Irrigation Devices on Removal of Smear Layer - A Systematic Review

Sagar Borse[1], Anita Sanap[1], Vini Mehta[2], Nikhil Borse[1], Swapnil Bhosale[1], Piyush Oswal[1]

ABSTRACT

Introduction: Various irrigation activation methods have been developed in order to provide effective delivery of irrigant. Effective irrigant delivery and agitation are prerequisites to promote root canal disinfection and debris removal from inaccessible areas and improve successful endodontic treatment. Objective: The aim of present review is to compare the effectiveness of different irrigation devices in removal of smear layer in an in vitro study design.

Material and methods: MEDLINE, the Cochrane library, Google Scholar and major journals were searched for studies from January 2005 to December 2015 to identify appropriate articles. A comprehensive search was designed, and the articles were independently screened for eligibility by two reviewers. In-vitro studies done on human extracted teeth evaluating removal of smear layer using different irrigating devices and using Scanning Electron Microscope (SEM) were included

Results: Total 142 articles were searched out of which 66 articles were selected after reading title and abstract. As a second step, full text papers were obtained. Finally a total of 16 articles were included after reading and evaluating full text papers, out of which 5 articles were excluded on basis of insufficient data and 11 articles were selected for final synthesis. Most of the articles supported machine assisted irrigation devices for removal of smear layer which can improve root canal therapy.

Conclusion: Machine assisted irrigation devices performed well in removal of smear layer.

Keywords: Irrigation Devices, Smear Layer Removal, SEM

INTRODUCTION

The micro-organisms play important role in the pathogenesis of pulp and periapical diseases.[1] The success of endodontic therapy depends on disinfection of the entire root canal system, which requires elimination of microorganisms and their byproducts and prevention of its re-infection. The disinfection of root canal is achieved by mechanical preparation along with the irrigating solutions.[2]

All instrumentation systems as well as rotary systems are ineffective in cleaning and shaping of all surfaces and irregularities within the canal system.[3] As they only clean central body of the canal, rest of the canal structures like lateral and accessory canals, canal fins, isthmi, and cul-de-sacs are untouched after completion of the preparation.[4] Additionally; instrumentation produces a 1 to 5µm-thick smear layer that can block dentinal tubules from irrigant and sealer penetration.[5] Mechanical instrumentation that leads to the formation of tissue debris and smear layer formation gives favorable environment for microorganisms to grow and disrupt the seal between the material and canal walls.

Direct contact of irrigating solution with the entire canal wall surfaces is necessary for effective action particularly for the apical portions of small root canals[6] and it was stated that enhancement of the flushing action is necessary to improve root canal cleanliness.[7]

Various irrigation activation methods have been developed in order to provide effective delivery of irrigant. Effective irrigant delivery and agitation are prerequisites to promote root canal disinfection and debris removal from inaccessible areas and improve successful endodontic treatment Irrigant volume and fluid flow dynamics are important factors that affect canal debridement.

So to achieve goal of irrigation various irrigation activation based on different working principles like positive pressure agitation, Negative pressure agitation, sonic and ultrasonic agitation has been introduced in recent years.

The evaluation of endodontic therapy protocols in terms of smear layer removal during chemico-mechanical disinfection is essential to establish evidence-based guidelines to improve clinical outcomes in endondontics.

Previous studies have pointed out the smear layer removal effectiveness of different irrigation devices during root canal treatment. However, no systematic review comparing the effectiveness of these irrigation activation devices during endodontic treatment has been conducted. The aim of this systematic review is to compare effectiveness of different irrigation devices in smear layer removal in an in-vitro study design.

MATERIALS AND METHODOLOGY

The methodology used in this systematic review includes

1 a literature search strategy,
2 selection criteria,
3 screening and data extraction.

The PRISMA (preferred reporting items for systematic reviews and meta-analyses) was followed in this systematic review.[8]

PICO

P - Participants: Extracted human teeth.
I - Intervention: Irrigation devices
C – Comparison: In between different irrigation devices
O – Outcomes: Removal of Smear layer

Literature search strategy

The search strategy covered electronic databases and the reference

[1]Department of Conservative and Endodontics, [2]Department of Public Health Dentistry, Dr. D.Y. Patil Dental College and Hospital, Pimpri, Pune, Dr. D.Y. Patil Vidyapeeth, Pune, Maharashtra, India.

Corresponding author: Dr. Vini Mehta, Dr. D.Y. Patil Vidyapeeth, Pune, Maharashtra, India

How to cite this article: Sagar Borse, Anita Sanap, Vini Mehta, Nikhil Borse, Swapnil Bhosale, Piyush Oswal. Effect of different irrigation devices on removal of smear layer - a systematic review. International Journal of Contemporary Medical Research 2017;4(6):1371-1377.

Sr. No.	Search strategy	Number of articles	Number of selected articles
1	Irrigation devices AND smear layer removal AND SEM	46	16
2	Irrigation devices AND debris removal AND SEM	23	12
3	Irrigation system AND smear layer removal AND SEM	13	12
4	Irrigation system AND debris removal AND SEM	16	9
5	irrigation activation system AND smear layer removal AND SEM	4	4
6	Irrigation activation system AND debris layer removal AND SEM	2	2
7	Irrigation activation devices AND root canal debridement OR root canal cleansing AND SEM	8	4
8	Irrigation activation devices AND root canal debridement OR root canal cleansing AND SEM	12	6
9	Irrigation activation techniques AND smear layer removal AND SEM	1	1
Total		142	66

Table-1: Detailed Search Strategy and Keywords

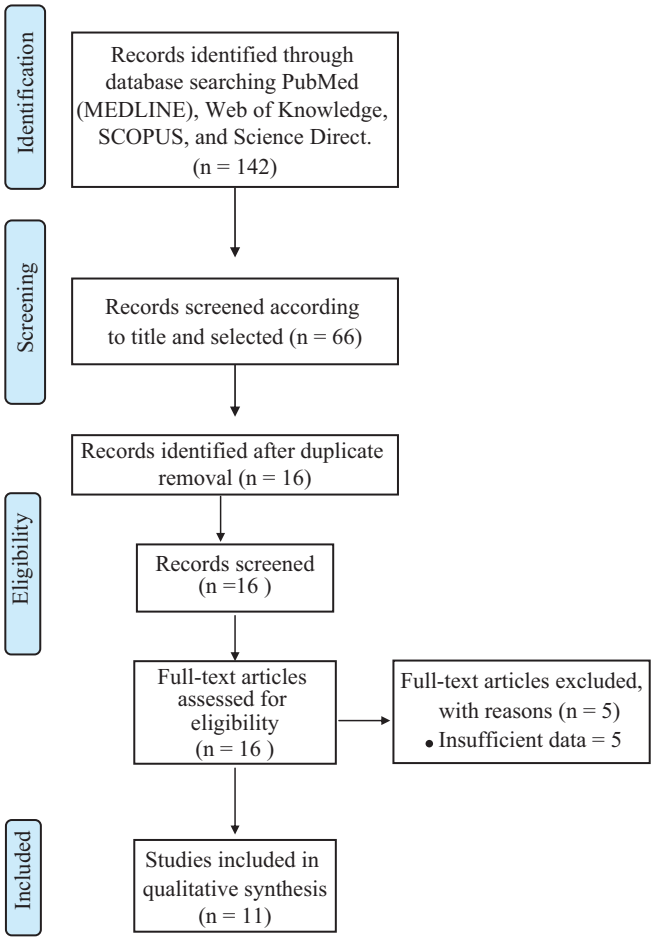

Figure-1: Flowchart summarizing the article selection process

lists of such articles identified and published from January 2005 to December 2015. The electronic databases searched were the following: PubMed (MEDLINE), the Cochrane library and Google Scholar. The following combination of key words were used: Irrigation devices AND smear layer removal AND scanning electron microscopy (SEM).

Inclusion criteria

1. Articles in English or those having detailed summary in English
2. In-vitro studies done on human extracted teeth.
3. Studies evaluating removal of smear layer using Scanning Electron Microscope (SEM)

Exclusion criteria:

Reviews, case reports, abstracts, letters to editors, editorials were excluded.

Screening and data extraction

Initially, potential relevant publications involving endodontic irrigants were retrieved independently by two reviewers (SB and AS). All articles were screened for eligibility criteria. Any disagreements were resolved by consensus after discussion with a third reviewer (VM). The extraction of information from studies were conducted by the same reviewers.

RESULTS

The results of the search strategy are presented in table 1. Figure 1 represent flow chart of systematic review process. Preliminary screening consisted total 142 articles out of which 66 articles were selected. For full-text screening, the following criteria were taken into consideration: In-vitro studies done on human extracted teeth in which smear layer removal evaluation was done using scanning electron microscopy (SEM) by using different irrigation devices. Finally a total of sixteen[9-25] articles were included out of which eleven[9-20] articles was finally synthesized in this systematic review.

All included articles were summarized in table 2.

DISCUSSION

The success of endodontic therapy depends on the substantial removal of vital and necrotic tissues, microorganisms, and their products from the root canal system. Chemo-mechanical debridement combining mechanical instrumentation with chemical irrigants can promote an adequate disinfection of the root canal systems during the endodontic treatment.[2] This is probably because of the significant reduction of intra canal microorganisms and necrotic tissues. As a limitation of all instrumentation technique to clean only main central canal, the un-instrumented areas like lateral canal, accessory canals, fins, apical deltas and ramifications remains infected, the disinfection in these areas can be achieved through chemical irrigation solution, but its accesses is affected by many factors like presence of smear layer, vapour lock effect, narrower diameter of the apical portion of canal. Traditional techniques of syringe irrigation fails to achieve the goal of disinfection.

So to increase efficacy of irrigation solution various irrigation activation devices has been introduced recently. They increases the efficacy, contact area and contact time of irrigating solution with root canal wall promoting it into inaccessible areas and achieving disinfection.

Author and Year	Sample size	No. of Groups	Irrigation devices	Groups	Irrigants Used	SEM Magnification	SEM Results	Results
Ghivari S. Kubasad G. and 2011	30	3	Syringe	i. NaviTip FX, iiSide vented needle, iii. single beveled needle	1 ml of 5.25% NaOCl in between instrumentation and ! ml of 5.25% NaO-Cl as final wash	30X and 200X	i. Apical 3.60±0.16 Middle: 2.04±0.16 Coronal 1.40±0.16 ii. Apical: 3.60±0.16 Middle: 1.70±0.15 Coronal 2.50±0.16 iii. Apical 3.70±0.15 Middle:2.30±0.26 Apical: 2.60±0.26	The brush covered needle: coronal third, side vented needle: middle third and single beveled needle failed to remove from any part
Bolhari B and 2014	60	3	Lasers	1.NaOCl + EDTA 2.Er,Cr:YSGG laser 1.5 W 3.Er,Cr:YSGG laser 2.5W 4.Positive Control Group	NaOCL +EDTA Saline for Laser no treatment for positive control	2000X	1. Coronal-15 middle 15 apical 15 2. Coronal-15 middle-15 apical-15 3. Coronal-15 middle-15 apical-15 4. Coronal-0 middle-0 apical-0.	Treatment with Er,Cr:YSGG laser showed a similar degree of effectiveness in smear layer removal to that of conventional EDTA and NaOCl
Zhu X. and 2013	48	5	PIPS	1.Normal Saline		300X 5000X	Coronal 3.75±0.46 Middle 4.00±0.54 Apical 4.38±0.52 Overall 4.04±0.55	PIPS-aided irrigation and syringe irrigation with NaOCl + EDTA can remove smear layer in coronal and middle thirds of single-rooted teeth, but cannot remove smear layer in the apical third
				2.NaOCL			Coronal 2.75±0.46 Middle 3.25±0.46 Apical 3.88±0.83 Overall 3.29±0.75	
				3.NaOCL + EDTA			Coronal 1.75±0.46 Middle 2.13±0.35 Apical 3.63±0.52 Overall 2.50±0.93	
				4.EDTA			Coronal 2.63±0.52 Middle 3.25±0.46 Apical 3.63±0.52 Overall 3.17±0.64	

Table-2: Overview of Included Studies

International Journal of Contemporary Medical Research
Volume 4 | Issue 6 | June 2017 | ICV (2015): 77.83 |
ISSN (Online): 2393-915X; (Print): 2454-7379

Continue

				5.CHX			Coronal 3.13±0.35 Middle 3.50±0.54 Apical 4.00±0.76 Overall 3.54±0.66		
				6.PIPS+NaOCL			Coronal 1.88±0.35 Middle 2.75±0.46 Apical 3.88±0.64 Overall 2.83±0.96		
Agarwal V. and 2011	36	4	Syringe and Ultra-sonic	1.hypodermic needle (control)	Normal saline 1% NaOCl 2.5% NaOC	2000X	Apical 2.44		PUI +1% NaOCI is effective than syringe irrigation with a higher concentration of 2.5% NaOCI.
				2.Passive ultrasonic irrigation			Apical 0.33		
				3.Syringe irrigation			Apical 1.89		
				4.Syringe irrigation			Apical 1.44		
Gade V. and 2013	20	2	syringe and negative pressure	1.Side Vented needle	2.5%NaOCl 17% EDTA	2000X	Coronal 2 Middle 2.5 Apical 3		EndoVac grp resulted in sig-nificantly less debris at apical third level compared with needle irrigation grp.
				2.EndoVac				Coronal 2.5 Middle 3 Apical 2	
Salman M.I. and 2010	50	5	Syringe and soni-care brush	2.Syringe 3.Syringe 4.Syringe 5.Sonicare	1.2mL of sterile water 2.2mL of 2.5% NaOCL 3.2mL of 2.5% Na-OCL and final rinse with 17% EDTA for 60 sec. 4.2mL of 2.5% Na-OCL and final rinse with 17% EDTA for 90 sec. 5.2mL of 2.5% Na-OCL and final rinse with 17% EDTA for 90 sec.	200X and 1000X		4	30 s of passive agitation of 17% EDTA + Sonicare CanalBrush resulted in debris removal and smear layer reduction
								Syringe: 2.7	
								Syringe: 2	
								Syringe: 1.7	
								Sonicare: 1.3	

Table-2: Overview of Included Studies

Continue

Divito E. and 2012	80	4	Lasers	1.Syringe	1.Saline 2.Distilled water 3.17%EDTA 4.17%EDTA	1000X and 2000x		70.45	Er:YAG laser used showed significantly better smear layer removal than syringe irrigation.
				2.Laser for 20sec cycle				46.18	
				3.Laser for 20 sec cycle				31.68	
				4.Lase for 40 sec cycle				13.7	
Vivan R.R. and 2010	20	2	1.RinseEndo	1.RinsEndo systems	Saline	1000X		Coronal 8.2 Middle 9.6 Apical 8.6	No difference between RinsEndo system and irrigation in the cleaning ability of root canal walls.
			2.Conventinal Syringe					Coronal 11.8 Middle 12.4 Apical 12.4	
Garip Y. and 2010	20	2	Canal brush	1.Conventional Syringe (Control)	1 mL of 5.25% NaOCl and 1 mL of 15% EDTA	1500X		Coronal 1.60±0.96 Middle 2.60±1.42 Apical 3.50±0.97	Irrigating with brushing tended to produce cleaner canal walls
				2.Canal Brush				Coronal 2.10±0.99 Middle 2.20±0.79 Apical 3.20±1.13	
Silva D.H.D and 2015	30	3	Canal brush and Endovac	1.Conventional Syringe (Control)	1% NaOCl and 17% EDTA	35X and 1000X		Coronal 3 middle 3 apical 4	None of irrigation/aspiration protocols could not remove debris and smear layer.
				2.Canal Brush				Coronal 4 middle 4 apical 4	
				3.EndoVac system				Coronal 3 middle 3 apical 4	
	40	4	Max I probe and Endovac and Endo-activator	1.Conventional Syringe (Control)	NaOCL +EDTA			2.8	Machine-assisted irrigation devices and activation of irrigant resulted in better irrigation at the apical third level in both quantity and quality
				2.Max-I-Probe				2.3	
				3.EndoActivator system				0.8	
				4.EndoVac system				0.4	

*PUI= Passive ultrasonic irrigation, SEM = Scanning electronic microscope, NaOCL= Sodium hypochlorite,
CHX= Chlorhexidine, PIPS= Photon induced photoacoustic, EDTA= Ethelyene diamine tetra acetic acid.

Table-2: Overview of Included Studies

Irrigation activation devices based on various principles like positive pressure, apical negative pressure, sonic and ultrasonic and lasers are reported in literature. The 11 studies included in this review have compared irrigation devices based on various principles with conventional needle.

Out of 11 articles included in this study only 1 article has compared different irrigating needles, other article compared Rinse-Endo system[11] and rest 10 articles have compared irrigation activation devices with conventional needle irrigation. 10 articles have compared efficacy of different irrigation activation devices with conventional needle additionally they have used different concentrations of sodium hypochlorite and the ethelyne diamide tetraacitic acid as irrigating solution.

The sodium hypochlorite and EDTA helps in removal of smear layer are better than normal saline and showing better result compared with saline.

Out of 11 articles selected for this systematic review 3 articles[17,19,20] compared EndoVac irrigation system with side vented needle in one study and used 2.5% NaOCL and 17% EDTA as irrigating solution and concluded that EndoVac system is better in all the aspect when compared to conventional needle irrigation[17], in another study using Endovac comaperd with canal brush and conventional syringe as control group and used 1% NaOCL and 17% EDTA as irrigating solution and they also concluded that Endovac is better as compared to canal brush and conventional needle irrigation[19], one more study included Endovac and compared it with Max-I probe, Endoactivator and conventional needle as control group and using NaOCL and EDTA and they concluded that EndoVac and EndoActivator performed much better than conventional needle and Max-I-probe. So machine assited irrigation systems performed much better than conventional needle.[20]

EndoVac showed better result as compared to other irrigating devices because of negative pressure it creates in the canal, which takes the irrigant to the full Working Length. As irrigant comes in direct contact with the entire dentinal walls, the results are in support of the literature and research showing the maximum efficacy of EndoVac.

Passive ultrasonic irrigation was mentioned in 1 article out of 11 articles selected for this study and they compared passive ultrasonic irrigation with conventional syringe irrigation using different concentrations (1% and 2.5%) of NaOCL. The mechanisms of acoustic streaming and cavitation was the rapid movement of particles of fluid in a vortex-like motion around a vibrating object. The fluid transportation from the apical to the coronal end, at a rate of a few centimetres per second, results in hydrodynamic shear stresses around the file and disrupts most biological material is the main reson for effectiveness of passive ultrasonic devices. So study concluded From the outcome of the present study it can be suggested that PUI with 1% NaOCI is more effective in removal of debris from the root canal system than syringe irrigation with a higher concentration of 2.5% NaOCI. Hence 1% NaOCI, which is more biocompatible.[15]

Sonic irrigation activation was used in one study and they compared EndoActivator and Max-I-Probe with endovac and conventional needle irrigation and used NaOCL and EDTA as irrigating solution and they concluded that endoactivator and endovac are more effective in cleaning the canal compared to max I probe and conventional needle.[20]

Lasers were compared in 3[16,18,10] articles out of which one article compared PIPS irrigation activation which uses Er:YAG laser with conventional needle irrigation using different irrigating solutions combination using NaOCL, EDTA, NaOCL+EDTA and CHX and concluded that no significant difference was found between PIPS and conventional needle irrigation.[16] Another study compared Er,Cr:YSGG laser different power output with conventional needle irrigation also they used NaOCL+EDTA for conventional group and saline for laser group and they concluded that conventional needle irrigation was better than Er,Cr:YSGG laser at any output used.[18]

One last study compared Er:YAG laser with different time interval (20sec and 40 sec) and 17% EDTA and they concluded that Er:YAG laser was better than conventional needle irrigation.[10]

Other than these devises used 3[11,12,19] articles compared canal brush devices, out of which 2[11,12] articles compared canal brush with conventional needle irrigation and they both concluded that canal brush was more effective than conventional needle irrigation. And 1[19] article compared canal brush with EndoVac and conventional needle in which they concluded that canal brush and conventional needle was not effective.

Out of 11 articles selected for this review only 1[13] article compared different types of irrigation needles like brush covered needle and side vented needle with conventional needle and they concluded that brush covered and side vented needle were effective as compared to conventional needle.

Limitations

Studies included in this systematic review evaluated smear layer removal using different irrigating devices should have followed same scoring criteria for SEM scores evaluation to give conclusive evidence.

Implication for future research

Further in vitro study required with larger sample size for better comparisons. The scoring criteria's used for evaluation of smear layer removal for scanning electron microscopy should be standardized.

CONCLUSION

Effective irrigant delivery and agitation leading to effective cleanliness are prerequisites for successful endodontic treatment. This systematic review presents an overview of the irrigant agitation methods currently available and their debridement efficacy. So on the basis of data available in this systematic review it can be concluded that machine assisted irrigation devices are more effective in removal of smear layer and can improve success of root canal therapy.

REFERENCES

1. Kakehashy S, Stanley HR, Fitzgerald RJ. The effect of surgical exposures of dental pulps in germ-free and conventional laboratory rats. Oral Surg Oral Med Oral Pathol. 1965;20:340-349.
2. Zehnder M. Root canal irrigants. J Endod. 2006;32:389-398.
3. Bystro m A, Sundqvist G. Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. Scandinavian Journal of Dental Research. 1981;1989,321–8.
4. Walton RE. Histologic evaluation of different methods of

enlarging the pulp canal space. J Endod. 1976;2:304–11.
5. Torabinejad M, Handysides R, Khademi AA, Bakland LK. Clinical implications of the smear layer in endodontics: a review. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics. 2002;94:658–66.
6. Violich DR, Chandler NP. The smear layer in endodontics - a review. Int Endod J. 2010;43:2–15.
7. Zehnder M. Root canal irrigants. J Endod. 2006;32:389–98.
8. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(7).
9. Salman MI, Baumann MA, Hellmich M, Roggendorf MJ, Termaat S. SEM evaluation of root canal debridement with Sonicare CanalBrush irrigation. Int Endod J. 2010;43:363-9.
10. DiVito E, Peters OA, Olivi G. Effectiveness of the erbium:YAG laser and new design radial and stripped tips in removing the smear layer after root canal instrumentation. Lasers Med Sci. 2012;27:273-80.
11. Vivan RR, Bortolo MV, Duarte MA, Moraes IG, Tanomaru-Filho M, Bramante CM. Scanning electron microscopy analysis of RinsEndo system and conventional irrigation for debris removal. Braz Dent J. 2010;21:305-9.
12. Garip Y, Sazak H, Gunday M, Hatipoglu S. Evaluation of smear layer removal after use of a canal brush: an SEM study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110:e62-6.
13. Ghivari S, Kubasad G. Root canal debris removal using different irrigating needles: an SEM study. Indian J Dent Res. 2011;22:659-63.
14. Ribeiro EM, Silva-Sousa YT, Souza-Gabriel AE, Sousa-Neto MD, Lorencetti KT, Silva SR. Debris and smear removal in flattened root canals after use of different irrigant agitation protocols. Microsc Res Tech. 2012;75:781-90.
15. Agrawal VS, Kapoor S. An in vitro scanning electron microscopic study comparing the efficacy of passive ultrasonic and syringe irrigation methods using sodium hypochlorite in removal of debris from the root canal system. J Ir Dent Assoc. 2012;58:156-61.
16. Zhu X, Yin X, Chang JW, Wang Y, Cheung GS, Zhang C. Comparison of the antibacterial effect and smear layer removal using photon-initiated photoacoustic streaming aided irrigation versus a conventional irrigation in single rooted canals: an in vitro study. Photomed Laser Surg. 2013;31:371-7.
17. Gade VJ, Sedani SK, Lokade JS, Belsare LD, Gade JR. Comparative evaluation of debris removal from root canal wall by using EndoVac and conventional needle irrigation: An in vitro study. Contemp Clin Dent. 2013;4:432-6.
18. Bolhari B, Ehsani S, Etemadi A, Shafaq M, Nosrat A. Efficacy of Er,Cr:YSGG laser in removing smear layer and debris with two different output powers. Photomed Laser Surg. 2014;32:527-32.
19. Mendonça DH, Colucci V, Rached-Junior FJ, Miranda CE, Silva-Sousa YT, Silva SR. Effects of various irrigation/aspiration protocols on cleaning of flattened root canals. Braz Oral Res. 2015;29.
20. Kumar VR, Bahuguna N, Manan R. Comparison of efficacy of various root canal irrigation systems in removal of smear layer generated at apical third: An SEM study. J Conserv Dent. 2015;18:252-6.

Source of Support: Nil; **Conflict of Interest:** None

Submitted: 09-06-2017; **Accepted:** 07-07-2017; **Published:** 17-07-2017