Indian Journal of Science and Technology, Vol 9(18), DOI: 10.17485/ijst/2016/v9i18/88543, May 2016
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Evaluation of Adaptation of Resin Composite Restorations Packed using Ultrasonic Vibration Techniques A Systematic Review

Sara Mohamed Hany*, Mai Mahmoud Yousry and Essam Abdel Hafiz Naguib

Faculty of Oral and Dental Medicine, Cairo University, Egypt;
dr.sarahany@gmail.com, maiyousry@hotmail.com, essamnaguib50@gmail.com

Abstract

Objectives: The aim of this systematic review was to evaluate the effect of ultrasonic packing techniques using on the adaptation of resin composite materials. **Methods**: Two electronic databases were searched without limitations through May2015. The terms Bulk packing, Sonic vibration, Dental marginal adaptation, Marginal assessment, Dental leakage, Void, and Composite resins were used. Screening through titles and abstracts was initially performed, and then articles that fulfilled the inclusion criteria were selected for a full-text assessment. **Findings**: The database search strategy retrieved fifty nine potentially eligible studies. No duplicated studies were found. Titles and abstracts were screened and studies that fulfilled the inclusion criteria were selected for a full-text assessment. Finally fifteen laboratory studies met the inclusion criteria and reference list for them was obtained. **Applications/Improvements**: Placement technique did not influence the adaptation of resin composite restorations. While the type of resin composite material influenced the extent of marginal adaptation. There is an interaction between the composition of the resin composite material and the application technique. The adaptation of new Sonic Fill system is promising and needs further investigations concerning its clinical longevity.

Keywords: Bulk Packing, Composite Resins, Dental Marginal Adaptation, Marginal Assessment, Sonic Vibration, Void

1. Introduction

Marginal integrity is crucial for the long-term survival of adhesively placed restorations. A major problem is polymerization shrinkage, which may initiate failure of the resin composite - tooth interface, resulting in interfacial gaps. Restoration placement techniques, although controversial, are widely regarded as influential in the modification of shrinkage stresses. Incremental placement of light-activated resin composite has been recommended to decrease overall contraction by reducing the bulk of the material cured at one time. It was also assumed that the thixotropic effects due to the application of ultrasound would reduce the development of stress by increasing material flow, thus enhancing wetting properties of composite resin materials leading to improved marginal quality[1]80 box-only Class II cavities were prepared mesially and distally in 40 extracted human molars using four different oscillating diamond coated instruments: (A.

Tight marginal seal still has to be the primary goal for the clinicians, because gap formation with restorative materials cannot be counteracted once happened. Although remarkable improvements have been conducted in the technology of resin composite materials, failures are still reported. Poor adaptation along the restoration margins have been established as one of the most common problems of posterior resin composite restorations[2]ormocer materials have been introduced over the past few years. The purpose of this study was to evaluate the marginal and internal adaptation of two ormocer restorative systems (Admira, Voco and Definite, Degussa.

The relatively high viscosity and the presence of voids in resin composite materials result in insufficient adaptation to the dental substrate which will probably affect the

*Author for correspondence

clinical performance of the material. Application of resin composite using ultrasonic vibration technique decreases the initial viscosity of the material, thus promoting adequate wetting and adaptation of the densely filled resin composite onto the dental substrate[3].

Some manufacturers of resin composites have recommended placing the restorative material in a single increment with 5 mm of thickness as they did not find a statistically significant difference between placing the material in increments or in bulk[4].

Oscillation energy has been proposed in as a new method to pack resin composite. The principle of this technique assumes that vibration lowers the viscosity of the resin, allowing the material to flow and easily adapt to the cavity walls in a similar way as a flowableresin composite[5].

SonicFill was introduced in the dental market and it combines the properties of a flowableresin composite with those of a universal resin composite. Oscillation energy temporarily increases the flowability of the resin composite to achieve precise filling of cavities, leads to rapid placement through a single increment up to 5mm due to reduced polymerization shrinkage, and thereby reduce the working time[6].

2. Materials and Methods

The PRISMA (Preferred Reporting Items for Systematic Review) statement was used as a reporting template as much as possible (Figure 1).

2.1 Data Collection

A systematic search of electronic databases was conducted using Pubmed and Google scholar up to May 2015 without limitations.

2.2 Criteria for Selection of Studies

Screening was performed to all the titles according to these inclusion criteria:

- In-vitro studies.
- Using only human teeth.
- Application of vibration during resin composite application.

The following exclusion criteria were applied inaddition

- Clinical evaluations.

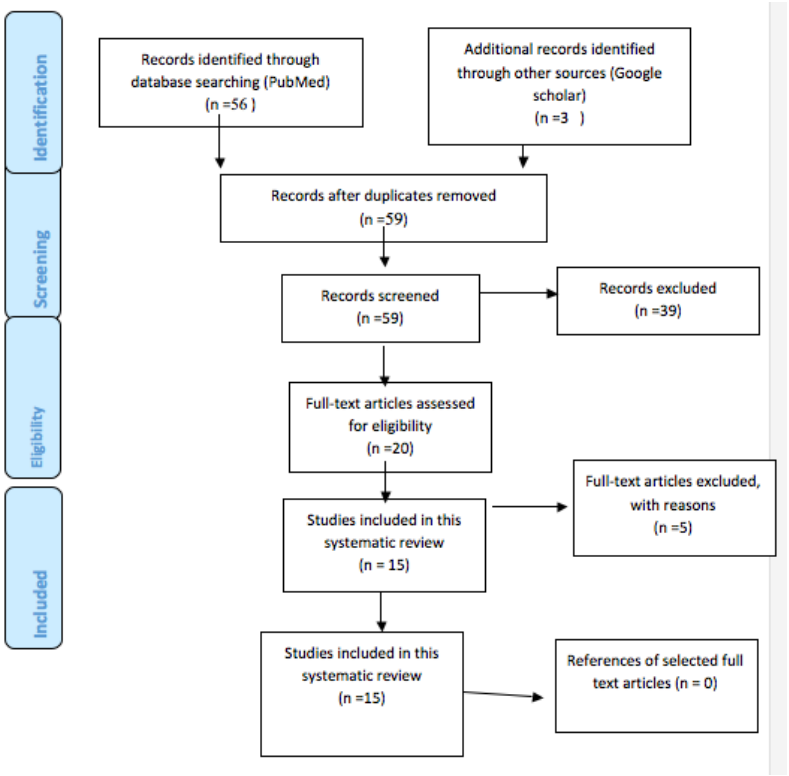

Figure 1. PRISMA 2009 flow diagram.

- Performing tests other than adaptation (eg: bond strength, hardness, cuspal deflection, depth of cure…….).
- Using language other than English.
- Using bovine teeth.
- Articles older than 2005.

A search with relevant title/abstract was conducted at the beginning (primary screening) followed by assessment of full articles (secondary screening) in order to select the included studies. An attempt was made to retrieve full articles for all potentially relevant abstracts that were already published, and those abstracts that were published with insufficient details were reported as N/A in the methodology table (Table 1).

2.3 Data Extraction

The fifteen studies[1,5–18] were analyzed with regard to type of teeth, sample size, resin composite materials, cavity classifications, placement technique, packing technique, method of adaptation assessment, adaptation assessment site and ageing.

2.4 Methodological Data among the Selected Studies

A customized systematic evaluation protocol (Table 1.) was created to compare the study methodology of the selected studies.

3. Results

Table 2 represents the results of the fifteen individual laboratory studies included in this systematic review.

3.1 Risk of Bias across Studies

Difference in the test parameters from one study to the other made it unable to perform meta-analysis.

4. Discussion

Manual and ultrasonic vibrational packing techniques were investigated in this systematic review in order to detect if the placement technique has an effect on the adaptation of resin composite restorations or not.

When it comes to the application method; one study[5] used the compothixo vibration condensation instrument which applies vibration after placement, four studies[1,7]Tetric, and Tetric Ceram[,8,16] used the ultrasonic vibrational tips, and the rest of the studies [6,9–15,17] used SonicFill system which applies vibration during the placement of the material.

With the Compothixo the vibration seemed to make the material more adherent to the instrument and more difficult to apply leading to formation of a hiatus at the interface between restoration and cavity walls[5].

Studies about SonicFill reported the benefits of sonic activation; low contraction stress, increase marginal integrity, reduce bulk fracture and no voids[10].

All studies reported the results of the marginal adaptation and microleakge whether in size of gap, dye penetration scoring or by describing the interface and all were well clarified methods for adaptation evaluation.

This systematic review denotes that despite the expected benefits of the ultrasonic packing techniques with highly-filled resin composite materials, yet ultrasonic packing was not significantly advantageous over manual packing technique, due to the occurrence of polymerization shrinkage (1.6-1.8%) with almost the same degree with all tested materials[19].

A study[8] found that ultrasonic packing technique resulted in better but not statistically significant different interfacial adaptation values compared to application without ultrasonics of condensable composites, and another study[6] found that SonicFill and Filtek Supreme composites did not differ regarding results of adaptation.

SonicFill placed in a single bulk increment showed in a study[10] equal marginal integrity compared to other manually placed bulk fill and conventional materials. While in another study[11] no significant difference was found between SonicFill bulk placed material and conventional incrementally packed material with regards to marginal imperfections, openings and cracks.

On the contrary, an article[1]80 box-only Class II cavities were prepared mesially and distally in 40 extracted human molars using four different oscillating diamond coated instruments: (A reported that ultrasonic energy significantly reduced the marginal gap. Another article[18] reported that the most favourable gap results were obtained when the application of the bulk-fill material took place using the activating sonic handpiece.

Among the fifteen selected studies, six compared the effect of bulk and incremental placement techniques of resin composite materials on the adaptation of resin composite restorations, five studies used only bulk placement

Table 1. Methodology Table

Author, Year	Type of teeth	Sample no.	Material						Cavity		Microscope					Placement technique		Packing technique		Gap Measurement site					Aging
			A1	B2	C3	D4	F5	G6	I	II	V	SEM	ESEM	Optical	Other	Increm-ental	Bulk	Manual	ultrasound	Occ.	axial	gingival	Faciopr-oximal	Lingo prox	
Schmidlin et al, in 20057Tetric, and Tetric Ceram	Human molars	48	ok			Ok	ok		ok			Ok				ok		ok	ok		ok				N/A
Hassan &Ghulman, in 20068	Human premolars	20				Ok			Ok					Ok		Ok		Ok	Ok		Ok				N/A
Schmidlin et al, in 2007180 box-only Class II cavities were prepared mesially and distally in 40 extracted human molars using four different oscillating diamond coated instruments: (A	Human molars	80	ok							OM or OD		Ok				ok		ok	ok			ok	ok	ok	49Nat 1.7Hz, 12,00000 thermal cycles(5-50 °C)
Iovan et al, in 20115	Human molars	20	ok						ok			Ok				Ok		ok	OK7						N/A
Eunice et al, in 20126	Human molars	30		ok	ok						Ok				OK8	Ok	3 mm	ok	ok						500 Thermal cycles (5-55°C)
Begino et al. in 20129	Human molars	25		ok										ok			5 mm		ok	ok		ok			100 thermal cycles (5-55 °C)
Frankenberger , in 201210	Human molars	64		Ok						MOD		Ok					5 mm		ok			ok	Ok	Ok	100,000× 50N mechanical cycles, 2,500 thermal cycles (5-55 °C)
Munoz-Viveros et al, in 2012 11	Human molars	15	ok	ok						ok		Ok				ok	ok	ok	ok			ok	Ok	Ok	1000 thermal cycles(5-55°C)

Campos, et al 201412impressions were made using a polyvinyl siloxane and epoxy resin replicas were obtained. Thermo-mechanical stressing was carried out 24 h after the restorative procedure. All specimens were submitted to 240,000 occlusal loading and simultaneous 600 thermal cycles in water at 5 ??C and 50 ??C. After loading, a new set of epoxy resin replicas was obtained. Scanning electron microscopy was carried out at 200?? magnification. Results for the marginal adaptation were expressed as percentages of continuity relative to the exposed interface and analyzed by ANOVA and Duncan post hoc test ($p < 0.05$	Human molars	40	Ok	Ok	Ok		Ok			Ok		Ok					Ok	Ok	Ok			Ok	Ok	Ok	240,000 mechanical cycles, 600 thermal cycles (5-50°C)	
Furness et al, in 201413	Huan molars	50		Ok	Ok		Ok		Ok						Ok[9]	Ok	Ok	Ok	Ok		Ok	Ok				
Yaroub& Hameed14, in 2014	Human premolars	36		Ok	ok	Ok						ok				Ok	Ok	Ok	Ok	Ok		Ok	Ok	Ok	50,000 Mechanical cycles	
Agrwal et al, in 201515	Human premolars	80		Ok	Ok		Ok			Ok		Ok				Ok	Ok	Ok	Ok			Ok	Ok	Ok	2500 thermal cycles (5-55°C)	
Benetti et al, in 201516	NA	N/A		Ok	Ok		Ok			Ok					ok		Ok	Ok	Ok			Ok	Ok	Ok	N/A	
Kim et al, in 201517	Human molars	N/A		Ok	Ok		Ok		Ok						Ok[10]	Ok	Ok	Ok	Ok		Ok	Ok			N/A	
Orlowski et al, in 201518	Human molars	30		Ok	Ok		Ok			Ok				Ok			Ok	Ok	Ok			Ok	Ok	Ok	N/A	

Table 2. Results table

Author, Year	Measurement of marginal gaps
Schmidlin[7]Tetric, and Tetric Ceram et al, in 2005	1) packable a- manual= 120-131 µm b- ultrasonic= 56-94 µm 2) microhybrid a- manual= 84-115µm b- ultrasonic= 63-99µm 3) flowable a- manual= 47-77µm b- ultrasonic= 49-74µm
Hassan &Ghulman, in 2006[8]	Manual 14.47±6.69 Ultra-sonic 10.97±5.07
Schmidlin et al, in 2007[1]80 box-only Class II cavities were prepared mesially and distally in 40 extracted human molars using four different oscillating diamond coated instruments: (A	% of continuous margin: -**proximally:** 1) without ultrasound: a) before loading 86-93% b) after loading 42-76% 2) with ultrasound: a) before loading 82-94% b) after loading 68-85% -**cervically:** 1) without ultrasound: a) before loading 72-89% b) after loading 40-77% 2) with ultrasound: a) before loading 73-93% b) after loading 36-86%
Iovanet al, in 2011[5]	manual packing: Inconsistent (areas of adequate adaptation alternating with areas of poor adaptation) -vibrational packing: appropriate adaptation to cavity walls with very small irregularities
Eunice et al, in 2012[6]	SonicFill = 0.08 Nanocomposite = 0.07
Begino et al. in 2013[9]	Occlusal = 0.1-2.3 mm Cervical = 0- 0.7 mm
Frankenberger , in 2013[10]	Gap free margin (%): Enamel = 100% Enamel TML= 84% Dentin= 98% Dentin TML = 60%
Munoz-Viveros[11]et al, in 2013	Sonic Fill had the least microleakage, it is void free, and equivalent marginal adaptation to incrementally applied materials

Campos, et al 2014[12]impressions were made using a polyvinyl siloxane and epoxy resin replicas were obtained. Thermo-mechanical stressing was carried out 24 h after the restorative procedure. All specimens were submitted to 240,000 occlusal loading and simultaneous 600 thermal cycles in water at 5 ??C and 50 ??C. After loading, a new set of epoxy resin replicas was obtained. Scanning electron microscopy was carried out at 200?? magnification. Results for the marginal adaptation were expressed as percentages of continuity relative to the exposed interface and analyzed by ANOVA and Duncan post hoc test ($p < 0.05$	No difference in marginal adaptation between bulk-fill material and standard composite
Furness et al, in 2014[13]	Sonic-Fill Bulk= 45 % gap free margins Sonic-Fill Incremental= 58% gap free margins
Yaroub& Hameed, in 2014[14]	Sonic fill™ bulk fill composite showed significantly lesser marginal gaps width at occlusal, proximal and gingival composite/enamel interface regions in comparison with packable composite using horizontal incremental technique.
Agrwal et al, in 2015[15]	Results of cervical enamel gap: Gr. I - Sonic Fill= 94.420±6.594 Gr. II – SDR= 93.380±7.010 Gr. III - Tetric N Ceram Bulk Fill= 92.130±5.852 Gr. IV - Tetric N Flo + Tetric N Ceram= 93.530±7.550
Benetti et al, in 2015[16]	Bulk-fill materials exhibited a gap formation similar to that of the conventional resin composite
Kim et al, in 2015[17]	The flowable composites exhibited higher shrinkage and lower modulus than the packable composites
Orlowski et al, in 2015[18]	90% of restorations of SonicFill system scored 0= no dye penetration

[1]Universal composite (hybrid)
[2]Sonicfill
[3]Nanocomposite
[4]Packable
[5]flowable
[6]microfilled
[7]Comp-othixo
[8]immersion in sodium pertechnetate for 3 hrs then radioactivity detected by gamma camera
[9]Digital Microscope
[10]Shrinkage-stress measuring instrument, Acousitc emission analysis

technique and four studies applied only incrementally placed materials.

These studies that compared the two placement techniques revealed no significant difference between the placement techniques regarding the adaptation of resin composite restorations.

This systematic review did not evaluate the effect of the resin composite material itself on the adaptation (the flow characteristics and the composition), but different between techniques was highlighted by manual packing and concealed by the ultrasonic packing techniques. This result could be explained by the difference in material properties as well as incremental versus bulk packing of the materials. With advances in new bulk-fill composite materials, shrinkage stresses at the margins are expected to be less, as a result of the ability of unpolymerized composite at the depth of the restoration to deform and "feed" the resulting stress development from the strain of composite curing at shallower depths. Thus, despite reduced volume of composite, higher stress development is expected to have occurred in the 2-mm thick incremental packing technique, with higher percentages of gap and less intact margins due to the absence of a deep reservoir of uncured composite from which polymerization stresses of the upper composite segment could be relieved[13].

As regarding flow of the material during setting; chemically activated materials had the upper hand as they polymerize more slowly and this give them greater capacity to flow during their longer gel stage so they generate lower stresses on the adhesive bond. During light curing, resin matrix is converted to a polymer network leading to closer packing and shrinkage. Shrinkage is compensated for after that by viscous flow until resin reaches its gel point. Viscous flow is reduced shortly after commencing light curing and stress is transferred to the cavity walls. After that shrinkage is largely counteracted by adherence and plastic flow. On the other hand the composition affects the light dispersion which is very critical especially in bulk placed materials; (increase micro-particles, increase light dispersion and reduced polymerization) in deep areas[1]80 box-only Class II cavities were prepared mesially and distally in 40 extracted human molars using four different oscillating diamond coated instruments: (A.

Gap reflects interaction between resin composite material (polymerization shrinkage, material flow during setting, composition), placement technique and contraction stress[20], so we need a material and a technique that can prevent contraction stress and both are still not present since the long term behavior of newly introduced SonicFill system is still unknown.

5. Conclusions

- Placement technique did not influence the adaptation of resin composite restorations.
- Type of resin composite material influenced the extent of adaptation.
- There is an interaction between the composition of the resin composite material and the application technique.
- The adaptation of new SonicFill system is promising and needs further investigations concerning its clinical longevity.

5.1 Recommendations

- Recent studies and clinical trials that evaluate different application techniques and bulkfill materials should be periodically reviewed[21–23].
- Data about different adaptation testing procedures should also be collected and reviewed whenever possible[24].

6. References

1. Schmidlin PR, Wolleb K, Imfeld T, Gygax M, Lussi A. Influence of beveling and ultrasound application on marginal adaptation of box-only Class II (slot) resin composite restorations. Oper Dent. 2007; 32(3):291–7. DOI: 10.2341/06-84.
2. Kournetas N, Chakmakchi M, Kakaboura A, Rahiotis C, Geis-Gerstorfer J. Marginal and internal adaptation of Class II ormocer and hybrid resin composite restorations before and after load cycling. Clin Oral Investig. 2004; 8(3):123–9. DOI: 10.1007/s00784-004-0274-3.
3. Cantoro A, Goracci C, Coniglio I, Magni E, Polimeni A, Ferrari M. Influence of ultrasound application on inlays luting with self-adhesive resin cements. Clin Oral Investig. 2011; 15(5):617–23. DOI: 10.1007/s00784-010-0451-5.
4. Poskus LT, Placido E, Cardoso PEC. Influence of adhesive system and placement technique on microleakage of resin-based composite restorations. J Adhes Dent. 2004; 6(3):227–32. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15536853
5. Iovan G, Stoleriu S, Moldovanu A, Morogai S, Andrian S. Sem study of the interface between the cavity wall and composite resin in cavities filled using vibration. Int J Med Dent. 2011; 1(3):254–8.

6. Eunice C, Margarida A, Joao C, et al. ^{99m}TC in the evaluation of microleakage of composite resin restorations with SonicFill^{TM}. An in vitro experimental model. Open J Stomatol. 2012; 2:340–7.
7. Schmidlin PR, Zehnder M, Schlup-Mityko C, Gohring TN. Interface evaluation after manual and ultrasonic insertion of standardized class I inlays using composite resin materials of different viscosity. Acta Odontol Scand. 2005; 63(4):205–12. DOI: 10.1080/00016350510019973.
8. Hassan MA, Ghulam MA. Effect of ultrasonic packing on interfacial adaptation of a densely filled resin composite in high c-factor cavities. Egypt Dent J. 2006; 52(1.2):1–7.
9. Begino R. SonicFill microleakage. Kerr Corp Fill Portf Sci Res; 2012. p. 7.
10. Frankenberger R. Marginal quality and associated cusp displacement of SonicFill restorations. Kerr Corp Fill Portf Sci Res; 2012. p. 2.
11. Munoz-Viveros C, Campillo-Funollet M. Microleakage of class II preparations restored with the sonicfill system. Kerr Corp Fill Portf Sci Res; 2012. p. 6.
12. Campos EA, Ardu S, Lefever D, Jasse FF, Bortolotto T, Krejci I. Marginal adaptation of class II cavities restored with bulk-fill composites. J Dent. 2014; 42(5):1–7. DOI: 10.1016/j.jdent.2014.02.007.
13. Furness A, Yousef M, Looney SW, Rueggeberg FA. Effect of bulk/incremental fill on internal gap formation of bulk-fill composites. J Dent. 2014; 42(4):439–49. DOI: 10.1016/j.jdent.2014.01.005.
14. Yaroub, Mais, Hameed MR. Evaluation of marginal gap at the composite/enamel interface in Class II composite resin restoration by SEM after thermal and mechanical load cycling (An in vitro comparative study). J Bagh Coll Dent. 2014 Dec; 26(4):63–70.
15. Agarwal R, Hiremath H, Agarwal J, Garg A. Evaluation of cervical marginal and internal adaptation using newer bulk fill composites: An in vitro study. J Conserv Dent. 2015; 18(1):56–61. DOI: 10.4103/0972-0707.148897.
16. Benetti AR, Havndrup-Pedersen C, Honore D, Pedersen MK, Pallesen U. Bulk-fill resin composites_ polymerization contraction, depth of cure, and gap formation. Oper Dent. 2015; 40(2):190–200.
17. Kim RJ-Y, Kim Y-J, Choi N-S, Lee I-B. Polymerization shrinkage, modulus, and shrinkage stress related to tooth-restoration interfacial debonding in bulk-fill composites. J Dent. 2015; 43(4):1–10. DOI: 10.1016/j.jdent.2015.02.002.
18. Orlowskii M, Tarczydlo B, Chalas R. Evaluation of marginal integrity of four bulk-fill dental composite materials: In Vitro Study. Sci World J. 2015; Article ID 701262:8 pages.
19. Loguercio AD1, Reis A, Schroeder M, Balducci I, Versluis A, Ballester RY. Polymerization shrinkage: Effects of boundary conditions and filling technique of resin composite restorations. J Dent. 2004 Aug; 32(6):459–70.
20. Idriss S, Abduljabbar T, Habib C, Omar R. Factors associated with microleakage in Class II resin composite restorations. Oper Dent. 2007; 32(1):60–6. DOI: 10.2341/06-16.
21. Jagadish L, Kumar VKA, Kaviyarasan V. Effect of triphala on dental bio-film. Indian Journal of Science and Technology. 2009 Jan; 2(1). DOI: 10.17485/ijst/2009/v2i1/29367.
22. Lee S-Y, Lim S-R, Cho Y-S. Remineralisation effect of fluoride on early caries lesions using a Quantitative Light-induced Fluorescence-Digital (QLF-D). Indian Journal of Science and Technology. 2015; 8(S1):457–61.
23. Mahajan G, Karve N, Patil U, Kuppan P, Venkatesan K. Analysis of microstructure, hardness and wear of Al-SiC-TiB_2 hybrid metal matrix composite. Indian Journal of Science and Technology. 2015; 8(2):101–5.
24. El-Din El-khodary NAM, Abd El-Meged Katamesh H, Halim DH. Invitro fracture resistance and marginal accuracy of zirconia inlay-retained fixed partial denture: A systematic review. Indian Journal of Science and Technology. 2016; 9(8):1–7.