Original Article

A comparative study to evaluate the marginal accuracy of provisional restorations fabricated by light polymerized resin and autopolymerized resin: A scanning electron microscope study

S. Nivedita, D. R. Prithviraj
Department of Prosthodontics and Implantology, Government Dental College, Fort, Bangalore - 560 002, India

For correspondence
S. Nivedita, Department of Prosthodontics and Implantology, Government Dental College, Fort, Bangalore - 560 002, India.
E-mail: neeta2379@rediffmail.com

BACKGROUND AND OBJECTIVES: To compare the vertical marginal discrepancy of provisional restorations fabricated using light polymerized composite resin by direct technique and provisional restorations fabricated using auto polymerized resin by direct and indirect technique. **MATERIALS AND METHODS:** A total of 45 provisional restorations were fabricated, 15- fabricated by using autopolymerized resin by direct technique on the metal dies and15- fabricated by indirect technique on stone dies. 15 - fabricated using light cured composite resin by direct technique on metal dies. Marginal discrepancies were calculated using scanning electron microscope (SEM). The restorations were then cemented using non-eugenol temporary cement and subjected to SEM analysis. **RESULTS:** Vertical marginal discrepancy of the provisional restorations fabricated using light cured composite resin by direct technique was least when compared to the vertical marginal discrepancy of the provisional restorations fabricated using autopolymerized resin by direct and indirect technique. Among the restorations fabricated using autopolymerized resin, marginal discrepancy observed with the indirect technique was less compared to the marginal discrepancy observed with direct technique. **CONCLUSION:** The vertical marginal discrepancy of the provisional restorations fabricated using light cured composite resins by direct technique was least and had a better marginal fit compared to the provisional restorations fabricated using autopolymerized resin by direct and indirect technique. The light cured resin could be a better material used to fabricate provisional restoration with an improved marginal adaptation.

Key words: Autopolymerized resin, light cured composite resin, marginal discrepancy, provisional restoration, Revotek-LC

Provisional restorations are designed to enhance esthetics, stabilization and/or function for a limited period of time after which it has to be replaced by a definitive prosthesis.

Provisional fixed prosthodontics treatment involves a multifaceted array of clinical activities, special knowledge, material selection and management.

Most commonly used provisional restorative materials are acrylic resins but they have their limitations. The newer light-activated materials have micro-silica incorporated, which improves the physical properties and reduces polymerization shrinkage.[1] This study was carried out to compare the marginal accuracy of provisional restorations fabricated using lightpolymerized resin by direct technique and autopolymerized resin by direct and indirect technique.

METHODOLOGY

Master dies

Ten stainless steel master dies representing five unprepared and five prepared teeth with a stainless steel base for mounting the master dies were fabricated.

The dimensions of the master dies were as follows.

Master dies	Height (mm)	Taper	Diameter (mm)	Shoulder (mm)	Offset angle for correct orientation of crowns
Master dies representing unprepared teeth	10	0^0	10	-	-
Master dies representing prepared teeth	8	6^0	-	1	30^0

Finish lines were placed 1 mm above the stainless steel base. A 30º cut was placed at the occluso-axial junction for orientation and identification.

1. Uniform thickness of the 2-sheet wax spacer was adapted over the master dies and autopolymerising acrylic resin impression tray was fabricated. The tray was extended to the orientation notches of the stainless steel base for proper seating of the tray.
2. A custom made device for seating the provisional crowns was used. A definite number of rotations were given to standardize the seating force.

MATERIALS AND METHODS

The test specimens were prepared as follows:

Direct technique

An irreversible hydrocolloid impression of the five unprepared teeth was made using the custom built tray and stored in a sealed plastic pouch. The dies representing the prepared teeth were placed onto the base and were smeared with petroleum jelly. Autopolymerising resin was mixed in the powder: liquid ratio of 3:1 and the material was placed in the indentation of the impression. When the resin mix reached the dough stage, the impression was reseated on the mounted dies. When the resin mix reached rubbery stage, the impression along with the resin was removed from the dies and allowed to set. On and off technique was employed to prevent the resin mix from adhering to the dies. When the material was completely set, the restorations were removed and excess was trimmed under magnification.

The restorations were then seated on the respective dies and the specimens were subjected to visual and SEM evaluation for the marginal adaptation.

Indirect technique

The stone replicas of mounted master dies representing the unprepared teeth and master dies representing the prepared teeth were prepared using irreversible hydrocolloid impression using custom made tray. Thin layer of separating medium was applied on the stone replica of prepared dies. An irreversible hydrocolloid matrix was prepared on the stone replicas of unprepared teeth, autopolymerising resin was mixed in Powder: Liquid ratio of 3:1, placed in the impression and seated on the dies representing the prepared teeth. A rubber band was placed around the base and impression assembly and allowed to harden.

Once the resin was hard, the restorations were separated from the stone replica and flash was neatly trimmed under magnification.The restorations were then seated on the master dies and subjected for visual and SEM evaluation.

Direct technique using light polymerized composite resin

A stent made of heat cure clear acrylic resin was formed over the unprepared dies. It was smeared with petroleum jelly and filled with the required amount of light polymerized composite resin [REVOTEK LC]. The stent with the light polymerized composite resin was placed onto the prepared dies and light-cured for 10 sec./ unit and then removed and final light-cured for 20 sec./ surface. The restorations were then trimmed and finished. The restorations were then seated on the respective dies and the specimens were subjected to visual and SEM evaluation for the marginal adaptation.

Methods of evaluation of marginal fit

The provisional restorations were evaluated for marginal fit on the same day of fabrication for all the crowns. Visual assessment of marginal fit was made. Area with least vertical marginal discrepancy was marked with a marker pen.

The master dies with provisional restoration were coated with 400Å of gold for obtaining surface clarity. The restorations were evaluated for marginal fit under scanning electron microscope. An accelerating voltage of 10 kv and 20 kv under magnification of ´250 was used for evaluation of marginal fit.

Cementation

The provisional restorations were cemented using non-eugenol based temporary cement [Temp Bond-NE]. Care was taken in proportioning the cement. Equal quantities of the base and catalyst material were taken, mixed thoroughly for 30 seconds. A thin layer was smeared on the inner aspect of the restorations. The provisional restorations were then seated on the respective master dies. The custom seating device was used and a definite number of rotations were given to the seating device to standardize the seating force. Following cementation, the provisional restorations along with the master dies were again coated with 400Å of gold. The area showing the best marginal fit before cementation was again subjected for SEM evaluation.

Image analysis

The photographs showing the marginal fit of the provisional restorations were scanned and marginal discrepancies were measured with the help of the computer system. Three readings showing the marginal discrepancies at three points were taken and average was calculated and shown as marginal discrepancy in microns.The results were subjected to statistical analysis.

RESULTS

The data and results of the study are presented in the Tables 1-7.

Table 1: Mean vertical marginal discrepancies of the provisional restorations fabricated using autopolymerized resin by direct technique before and after cementation

Sample (n)	Mean (μm) before cementation	Mean (μm) after cementation
1	175	275
2	162.5	312.5
3	181.25	337.5
4	147.5	437.5
5	112.5	337.5
6	147.5	325
7	112.5	337.5
8	200	442
9	147.5	337.5
10	112.5	175
11	200	375
12	112.5	312.5
13	200	337
14	200	375
15	187.5	262.5

Table 2: Mean vertical marginal discrepancy of the provisional restorations fabricated using autopolymerized resin by indirect technique before and after cementation

Sample (*n*)	Mean (μm) before cementation	Mean (μm) after cementation
1	112.5	137.5
2	87.5	262.5
3	100	250
4	125	225
5	100	187.5
6	87.5	187.5
7	175	200
8	137.5	225
9	143.75	312.5
10	131.5	225
11	87.5	250
12	137.5	231.25
13	118.75	262.5
14	150	225
15	125	212.5

Table 3: Mean vertical marginal discrepancy of the provisional restorations fabricated using light polymerized composite resin by direct technique before cementation

Sample (*n*)	Mean (μm) before cementation	Mean (μm) after cementation
1	100	225
2	75	193.5
3	100	237.5
4	75	225
5	156.25	225
6	75	250
7	156.5	237.5
8	75	177.5
9	156.25	250
10	100	212.5
11	112.5	206.25
12	75	250
13	143.75	275
14	75	250
15	156.25	275

DISCUSSION

Provisional restorations are an indispensable and demanding interim solution, which call for high-quality materials and great care on the part of the dentist. The functions, which a provisional restoration must fulfill, are wide-ranging and demanding. They basically correspond to those of the final restoration, albeit only for a limited period of time.

The oldest groups of polymer-based direct provisional restorative materials are the acrylic MMA / PMMA resins. These have the advantages of good wear resistance, good colour stability, high polishability and good esthetics. Although these materials meet most of the requirements and are popular even today, their uses seem to be on decline because of their shortcomings and development of new and improved materials. Their high level of monomer release should not be underestimated, in particular when regarding the application to the freshly prepared tooth using the direct technique; monomer is an irritant to both soft tissue and pulp.[2-4] Thus it is the preferred material when restorations are made using the indirect technique. The exothermic reaction during setting requires the early removal of the temporary restoration from the preparation. This predisposes to the problem of unsatisfactory fit due to the subsequent polymerization shrinkage.

The visible light polymerized materials, first introduced in the 1980s,[5] contained urethane dimethacrylate, a resin whose polymerization is catalyzed by visible light and camphoroquinone as initiator.[6-8] Materials usually incorporate filler such as microfine silica to improve physical properties like reduced polymerization shrinkage.[1] Unlike methacrylate resins they do not produce residual free monomer after polymerization, which explains why they exhibit decreased tissue toxicity.[9] Haddix[10] indicated that VLC materials could produce provisional restorations with a similar quality but with less time and expense. With the recent developments in the temporization, a further milestone was achieved with the development of light cured composite resin, which is a visible light activated, single-component and sculptable material [(REVOTEK LC). Introduced by GC America in 2002]. It is supplied in a putty stick form and contains UDMA resin. The advantages claimed by the manufacturer are:

- No MMA, no odor, no exothermic, no irritation.
- Unlimited working time, no time required for mixing.
- Superior handling, easy to place, contour, sculpt and shape.
- Reduced polymerization shrinkage [0.388%].

Because of the above properties, this material can be employed to fabricate a better provisional restoration by direct technique with an accurate marginal fit.

This polymerization shrinkage observed with PMMA

Table 4: Shows the mean, standard deviation and range for comparison of marginal discrepancies before and after cementation for each group

	Material and methods	*n*	Mean (µm)	Standard deviation	Range
Before	Autopolymerized resin – direct technique	15	159.91	35.18	112.5-200
	Autopolymerized resin – indirect technique	15	121.26	25.75	87.5-175
	Light polymerized composite resin – direct technique	15	108.76	35.20	75-156
After	Autopolymerized resin – direct technique	15	331.93	65.79	175-442
	Autopolymerized resin – indirect technique	15	232.91	37.68	312-137
	Light polymerized composite resin – direct technique	15	225.98	31.32	177-275

Table 5: Shows the comparison of mean, standard deviation, '*t*' value, '*P*' value for each group before and after cementation

Groups compared	Comparison	Mean (µm)	Standard deviation	'*t*' value	'*P*' value	Inference
Restorations fabricated using autopolymerized resin by direct technique	Before and After	159.91 331.93	35.18 65.79	10.71	0.001	Significant
Restorations fabricated using autopolymerized resin by indirect technique	Before and After	121.26 232.91	25.75 37.68	8.84	0.001	Significant
Restorations fabricated using light polymerized composite resin by direct technique	Before and After	108.76 225.98	35.20 31.32	12.49	0.001	Significant

Table 6: Pair wise comparison of discrepancies observed before and after cementation using autopolymerized resin by direct and indirect technique

Comparison	Groups compared	Mean (µm)	Standard deviation	'*t*' value	'*P*' value	Inference
Before	Autopolymerized resin:	159.91	35.18	3.43	0.002	Significant
	Direct technique *vs.* Indirect technique	121.26	25.75			
After	Autopolymerized resin:	331.93	65.79	5.05	0.001	Significant
	Direct technique *vs.* Indirect technique	232.91	37.68			

Table 7: Pair wise comparison of discrepancies observed before and after cementation using autopolymerized resin and light polymerized composite resin by direct technique

Comparison	Groups compared	Mean (µm)	Standard deviation	'*t*' value	'*P*' value	Inference
Before	Autopolymerized resin by direct technique *vs.* Light polymerized composite resin by direct technique	159.91 108.76	35.18 35.20	3.98	0.001	Significant
After	Autopolymerized resin by direct technique *vs.* Light polymerized composite resin by direct technique	331.93 225.98	65.79 31.32	5.6	0.001	Significant

resin could be attributed to:

- The setting reaction, where the material undergoes an increase in density causing volumetric contraction.
- Thermal shrinkage from a higher polymerization temperature to a lower room temperature.

The mean vertical marginal discrepancy of provisional restorations fabricated using autopolymerized resin by direct technique was higher when compared to the mean vertical marginal discrepancy of provisional restorations fabricated by indirect technique.

The probable reason for this finding could be attributed to:

- In the direct technique, the provisional restorations were separated from the master dies before they were set and later reseated for complete polymerization. This method of separating the resin mix from the master dies before it was set could have caused distortion, as there is no supporting substructure.
- In spite of the maximum care, variation in the thickness of the restorations fabricated was observed and not taken into consideration; this variation can alter the amount of polymerization shrinkage and could have led to the discrepancy.
- During the polymerization, the shrinkage of the resin occurs towards the center of the mass, thus the margins of the provisional restorations are liable to get lifted away from the finish line leading to vertical and horizontal marginal discrepancy.
- Definite number of rotations was given during seating, to have a uniform seating pressure; however the variation in the thickness of the material might have led to the variation in the amount of force applied. This could have led to the variations in the vertical marginal discrepancy observed within the group.

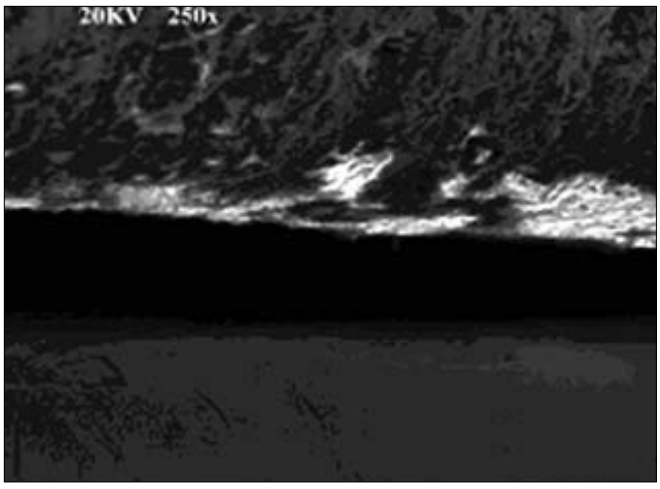

Figure 1: Photograph showing vertical marginal discrepancy of the provisional restorations fabricated using autopolymerized resin by direct technique.before cementation

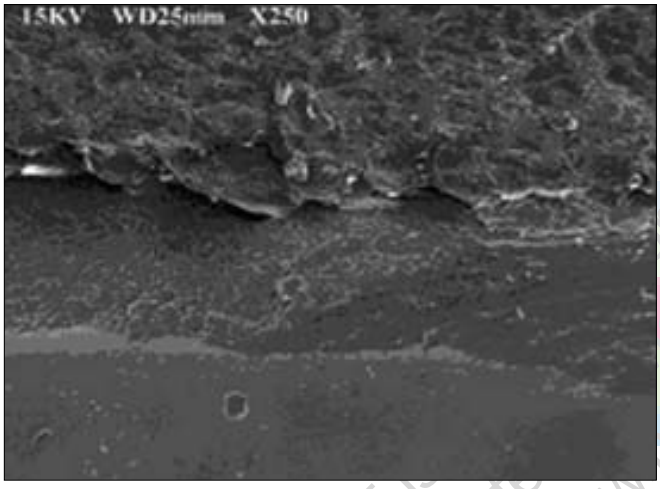

Figure 2: Photograph showing vertical marginal discrepancy of the provisional restorations fabricated using autopolymerized resin by direct technique after cementation

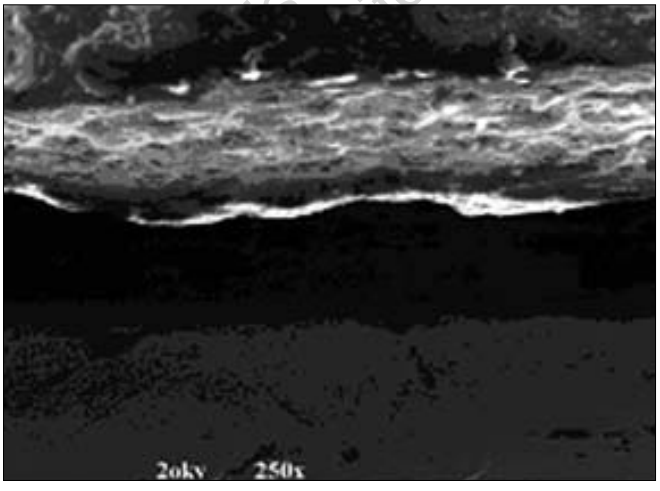

Figure 3: Photograph showing vertical marginal discrepancy of the provisional restorations fabricated using autopolymerized resin by indirect technique.before cementation.

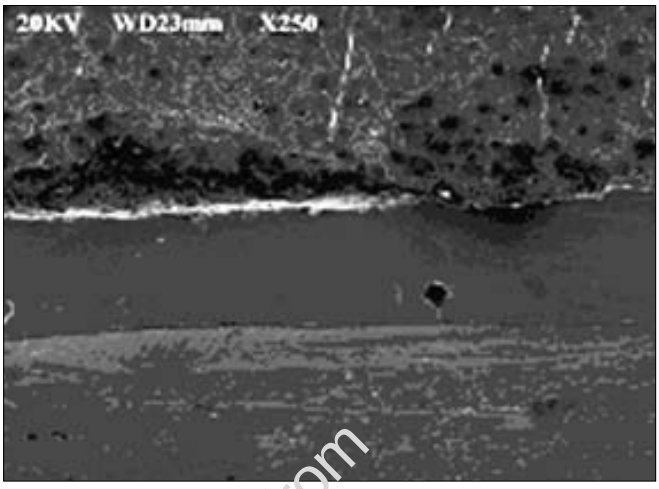

Figure 4: Photograph showing vertical marginal discrepancy of the provisional restorations fabricated using autopolymerized resin by indirect technique.after cementation

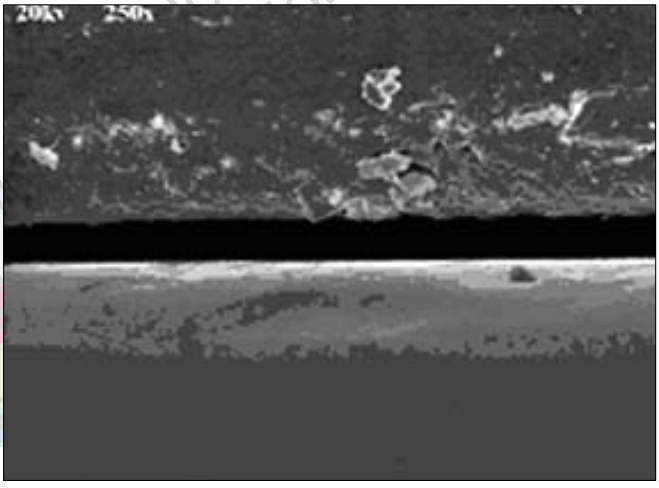

Figure 5: Photograph showing vertical marginal discrepancy of the provisional restorations fabricated using light polymerized resin by direct technique before cementation

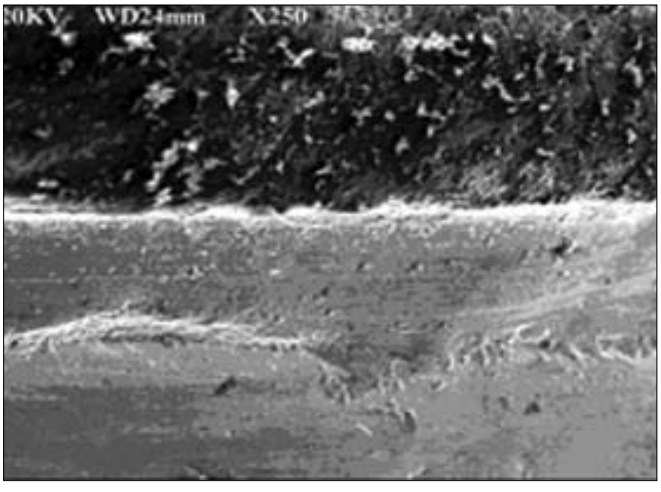

Figure 6: Photograph showing vertical marginal discrepancy of the provisional restorations fabricated using light polymerized resin by direct technique after cementation

- The variation in the thickness could be due to the variation in the amount of resin material taken in the impression and compressibility of the irreversible hydrocolloid material.

However, the mean vertical marginal discrepancy of provisional restorations fabricated by indirect technique was significantly better, this could be due to:

- The resin mix was left undisturbed on the stone dies during polymerization.
- That the stone restricted the resin shrinkage during polymerization, as stone acted as a supporting substructure.
- The setting expansion of the stone dies could also have compensated to a limited extent for the polymerization shrinkage.

Further it was observed that the mean vertical marginal discrepancy of provisional restorations fabricated using light cured composite resin [REVOTEK LC] by direct technique was 108.76 µm when observed before cementation [Figures 1, 3, 5]. The decreased shrinkage observed with the light cured composite resin could be attributed to:

- The absence of free monomer and presence of the fillers like microsilica, which reduces the polymerization shrinkage.[1]
- This could be also due to the presence of higher concentration of cross-linking agents present in the material.
- The provisional restorations were fabricated on the master dies without separating during polymerization. This could have resulted in a better marginal fit and reduced marginal discrepancy.

In general all the provisional restorations showed an increase in the mean vertical marginal discrepancy after cementation [Figures 2, 4, 6]. This could be attributed to the fact that:

- The provisional restorations were not conditioned in water after their fabrication. The continued polymerization could have led to greater shrinkage.
- No provision was made for compensating the thickness of the luting cement.

CONCLUSION

Within the limitations of the study by analyzing the results, it was concluded that:

- The mean vertical marginal discrepancy of the provisional restorations fabricated using light cured composite resin [REVOTEK LC] by direct technique was least compared to the mean vertical marginal discrepancy of the provisional restorations fabricated using autopolymerized resin by direct and indirect technique.
- Among the restorations fabricated using autopolymerized resin, the mean vertical marginal discrepancy of the provisional restorations fabricated by indirect technique was less compared to the mean vertical marginal discrepancy of the provisional restorations fabricated by direct technique.
- The marginal fit obtained with the provisional restorations fabricated by light cured composite resin by direct technique was better compared to the marginal fit obtained with the provisional restorations fabricated using autopolymerized resin by direct and indirect technique. The light cured composite resin [REVOTEK LC] could be a better material to fabricate provisional restoration with an improved marginal adaptation.
- The various materials used to fabricate the provisional restoration do not fulfill all the requirements. They have their own merits and demerits, yet they are all popular. Their successful outcome also depends largely on the skill of the operator and the technique employed.

REFERENCES

1. Passon C, Goldfogel M. Direct technique for the fabrication of a visible light curing resin provisional restoration. Quintessence Int 1990;21:699-703.
2. McLean WJ, Kramer RH. Clinical and pathological evaluation of sulfinic acid activated resin for use in restorative dentistry. Br Dent J 1952;18:255-69.
3. Suarez CL, Stanley HR, Gilmour HW. Histopathologic response of the human dental pulp to the restorative resins. Am Dent Assoc 1970;80:792.
4. Langeland LK, Langeland K. Pulp reactions to crown preparations, impression, temporary crown fixation and permanent cementation. J Prosthet Dent 1965;15:129-43.
5. Emtiaz S, Tarnow DP. Processed acrylic resin provisional restoration with lingual cast metal framework. J Prosthet Dent 1998;79:484-8.
6. Gegauff AG, Wilkerson JJ. Fracture toughness testing of visible light and chemical initiated provisional restoration resins. Int J Prosthodont 1995;8:62-8.
7. Prestipino V. Visible light cured resins. A Technique for provisional fixed restorations. Quintessence Int 1989;20:241-8.
8. Ireland MF, Dixon DL, Breeding LC, Ramp MH. In vitro mechanical property comparison of four resins used for fabrication of provisional fixed restorations. J Prosthet Dent 1998;80:158-62.
9. Khan Z, Razavi R, Von Fraunhofer JA. The physical properties of visible light cured temporary fixed partial denture material. J Prosthet Dent 1988;60:543-5.
10. Haddix JE. A technique for visible light cured provisional restorations. J Prosthet Dent 1988;59:512-4.

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