

A comparative evaluation of Direct Composite with Indirect Composite in terms of Microleakage in class II MOD cavities: An in vitro study

Eishita Negi ¹, Nidhi Aggarwal ², Priti Gupta ³, Roseka⁴

¹ PG student, Department of Conservative Dentistry and Endodontics, Himachal Institute of Dental Sciences, Paonta Sahib (H.P), India

² Professor and Head, Department of Conservative Dentistry and Endodontics, Himachal Institute of Dental Sciences, Paonta Sahib (H.P)

³ Professor, Department of Conservative Dentistry and Endodontics, Himachal Institute of Dental Sciences, Paonta Sahib (H.P)

⁴ Reader, Department of Conservative Dentistry and Endodontics, Himachal Institute of Dental Sciences, Paonta Sahib (H.P)

ARTICLE INFO



Keywords: Resin composites, indirect composite, microleakage, esthetic, posterior restorations

ABSTRACT

Dental composite formulations have been continuously evolving ever since Bis-GMA was introduced to dentistry by Bowen in 1962. Recent developments have considerably improved the physical properties of resin-based composites and expanded their clinical applications. Indirect composite restorations offer an esthetic alternative for large posterior restorations. The aim of this in vitro study was to evaluate the direct and indirect composite in terms of microleakage in class II MOD cavities.

Introduction

In recent years, there has been an increased demand for aesthetic treatments; resin composite restorations have become the restorative material of choice for both anterior and posterior teeth. Despite their success in anterior teeth, direct composite restorations have exhibited more leakage and post-operative sensitivity when applied to posterior teeth, due to polymerization shrinkage. In addition, there are some problems in obtaining adequate proximal contact. Indirect composite restorations could present several advantages: better anatomic contour and proximal contact improved polishing and better esthetics. Additionally, since a higher degree of conversion is obtained, improved mechanical properties can result.^[1,2]

Microleakage is an important property that has been assessing the success of any restorative material used in restoring the tooth. Polymerization shrinkage is one of the primary deficiencies of composite restorations. It causes contraction stress within the restoration that leads to the microleakage, as well as stress within the surrounding tooth structure.^[3,4]

Hybrid composites were developed to obtain even better

surface smoothness than that provided by the small-particle composites, while still maintaining the desirable properties of other generations. TE Econom Plus is one such direct composite that falls under this category and can be used for restorative treatment of classes I to V, however, they are widely employed for stress-bearing and posterior restorations.^[5,6]

Composites with improved depth of cure and reduced shrinkage characteristics for bulk fill purposes have been introduced. All bulk-fill composites need to exhibit low shrinkage stress and thus good marginal integrity, adequate resistance to chewing forces in the posterior region, adequate working time in ambient light, adequate radiopacity, plus good polishing properties and aesthetic & can be applied in "bulk" increments of up to 4 mm without any adverse effect on the material's polymerization behavior or mechanical properties via incorporating advanced composite-filler technology, a pre-polymer shrinkage stress reliever, the photoinitiator Ivocerin® (polymerization booster), and a light sensitivity filter.^[7,8]

Recently, the second generation of indirect composites

(glass polymers) has been made available to clinicians. These new materials are reported as hybrid materials between composite and ceramic; however, they are composed of a resinous matrix with different inorganic fillers. SR Nexco (Ivoclar Vivadent, Schaan, Liechtenstein) was introduced in 2012 & has been extensively used in the fabrication of framework-free dental restorations (inlays and onlays).^[9]

This study evaluated the microleakage of indirect composite materials when compared to direct composite restorations in margins located in enamel and dentin.

METHODS AND MATERIALS

Seventy freshly extracted premolar teeth indicated for orthodontic/ periodontal extraction collected from the Department of Oral & Maxillofacial Surgery, Himachal Institute of Dental Sciences, Paonta Sahib (H.P) were selected for the present study. After soft tissue removal, the teeth were stored and refrigerated in distilled water until testing. Also, the teeth were free of cracks as evaluated under a surgical stereomicroscope with (10x) magnification.

Cavity Preparation

Specimens were collected and stored in saline till usage. Mesio-occlusal-distal preparation was done by using carbide bur (no.271, 169L) in a water-cooled high-speed air turbine handpiece. Class II box-only cavities were prepared on the mesial and distal surfaces of each tooth. Each tooth was mounted in an acrylic block with one premolar on the mesial side to simulate the posterior teeth alignment and a universal Tofflemire matrix band and retainer were placed around each tooth.

The MOD preparation was as per the modification in the adoptive protocol in the following dimension:

- a) Pulpal depth: 2mm±0.2mm
- b) Gingival width: 1.5mm±0.2mm axially
- c) Buccolingual width: 2mm±0.2mm
- d) Buccal and lingual wall: (6°) taper

Specimens taken for the study were randomly divided into 2 groups, the experimental group (n=70) and the control group (n=10). Mesio-occlusal-distal cavity preparation was done in all the teeth except for the negative control (n=5) which were the intact teeth. The positive control (n=5) was taken as the teeth on which the MOD cavity was prepared but not restored.

Restoration of samples:

Group 1: (SR Nexco composite)

Inlay Fabrication: Impressions were made from each cavity preparation using condensation silicone to produce stone dies that were used to prepare the composite inlays. SR Nexco composite was applied to the cavity walls and floor in a thick coat and each segment was cured for 20 seconds using a light-emitting diode curing unit (LED) with a wavelength between 430 and 490 nm (Woodpecker). The process of building up the cavity was continued in increments. After completing the layering procedure, all layers were cured in each direction for 20 seconds. After this, the restorations were placed in the furnace (Bre. Lux Power Unit 2) that was used for the final polymerizing of the restorations according to manufacturer instructions. After completion of the polymerization procedure, each restoration was carefully removed from the model and finished with carbide burs and fine diamonds using low speed and light pressure.

Indirect Restoration Luting: Luting was performed with RelyX ARC resin cement (3M ESPE). Tooth surfaces were conditioned with 35% phosphoric acid (3M ESPE) etching for 15 seconds. The surface was washed and gently dried, keeping it moist. Two coats of the adhesive system Single Bond (3M ESPE) were applied and photo-cured for 20 seconds. RelyX ARC (3M ESPE) was dispensed, mixed, and applied to the internal surface of the inlay. Excess cement was removed with scalers before light curing the interfaces for 40 seconds.

Group 2: (Tetric N Ceram bulk fill) Tofflemire retainer and band were adapted on the tooth. Etching was done on the prepared samples. A bonding agent was applied using a disposable brush and light-cured for the 20s. The cavity was filled with Tetric N Ceram bulk-fill composite to the prepared cavity depth. Light polymerization was done with the use of LED light (woodpecker) spectrum 440-490nm, power 900mW/cm². Tofflemire retainer and band were removed and curing was done for 20 seconds.

Group 3: (TE Econom Plus) Tofflemire retainer and the band were adapted on the tooth. Etching was done for the prepared samples. A bonding agent was applied using a disposable brush and light-cured for the 20s. The cavity was filled with TE Econom plus composite (IVOCCLAR VIVADENT) to a thickness of 2mm. Light polymerization was done with the use of LED light (woodpecker) spectrum 440-490nm, power 900mW/cm². Tofflemire retainer was removed and curing was done for 20 seconds from the mesial surface of the tooth.

Finishing of the samples: After the restoration of all the teeth, the restoration was finished with a fine-grit diamond bur, mounted in a turbine with a water spray, and polished with graded abrasive discs and a Super snap composite finishing kit (Sofu, Japan) in a contra-angle handpiece with water spray.

Evaluation of Microleakage: The specimens were thermocycled between 5°C and 55°C (dwell time of 30 seconds) for 500 cycles using a thermal cycling machine. Two coats of nail varnish were then applied to the entire surface of each tooth, except for the margins of the restorations and 1 mm around them. The teeth were immersed in a 2% methylene blue solution for 24 hours. Upon removal from the dye solution, the teeth were washed in tap water for 12 hours. The nail varnish was removed and the teeth were embedded in a clear acrylic resin. Each tooth was then sectioned mesiodistally with a diamond disc in a slow speed handpiece (NSK) into 2 sections allowing for the evaluation of 4 surfaces. The section with the deepest penetration was selected to represent the tooth. The extent of dye penetration was determined by examination under a stereomicroscope and industrial digital camera by a blind observer.

Scoring criteria: All specimens were examined under a stereomicroscope to measure the extent of dye penetration in Enamel and Dentin Margins:-

- Grade 0:- No penetration
- Grade 1:- Restricted to the cervical wall
- Grade 2:- Restricted to the axial wall
- Grade 3:- Reaching the pulpal wall

Data was collected and microleakage was evaluated on basis of scores.

Statistical Analysis

The statistical analysis was done using Statistical Package for the Social Sciences (SPSS for Windows, Version 16.0. Chicago, SPSS Inc.). Comparison of microleakage was done using the Kruskal-Wallis test followed by the Mann-Whitney U test for multiple comparisons. The level of significance for the present study was fixed at a p-value of less than 0.05.

RESULTS AND OBSERVATIONS

Table 1 shows the Kruskal-Wallis analysis for microleakage scores comparison among the study groups, with a statistically significant difference in mean microleakage

scores ($P < 0.001$). Maximum mean microleakage was seen associated with positive control followed by Group C, Group B, and Group A.

Graph 1 shows the mean microleakage score of different groups at the gingival margins.

Thereafter, the Mann-Whitney U test was carried out for multiple comparisons (Table 2) which revealed the following findings ($P < 0.05$):

- There was a statistically significant difference in mean microleakage scores between Group A and Group B ($P < 0.001$).
- There was a statistically significant difference in mean microleakage scores between Group A and Group C ($P < 0.001$).
- There was no statistically significant difference in mean microleakage scores between Group A and negative control ($P = 0.097$).
- There was a statistically significant difference in mean microleakage scores between Group A and positive control ($P < 0.001$)

Stereomicroscope images:

These images show the dye penetration for various groups. Figure 1a shows the dye penetration for Group A (SR NEXCO)

Figure 1b shows the dye penetration for group B (Tetric N Ceram)

Figure 1c shows the dye penetration for group C (TE Econom plus)

DISCUSSION

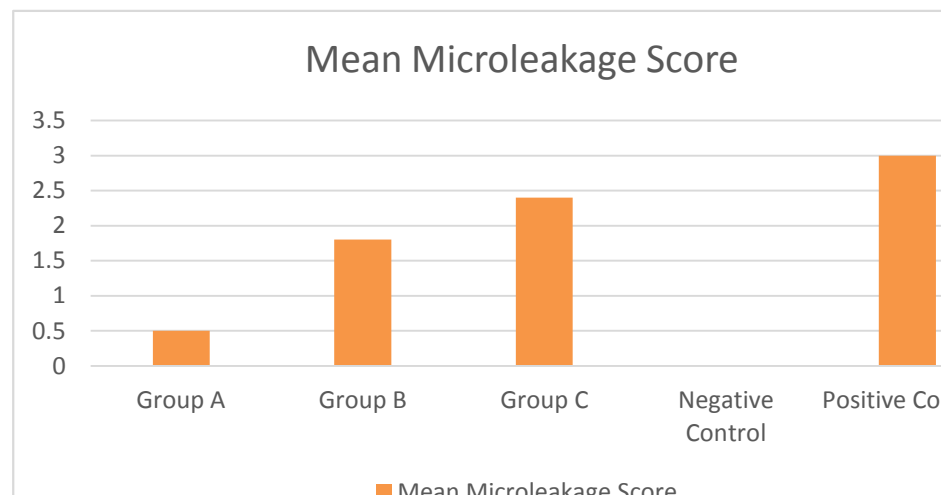
Composite resin defines the essence of modern conservative dentistry. The scope of restorative materials continues to proceed through an evolutionary process that is fuelled by the desire for less technique-sensitive materials. Thus making them widely used dental materials since they restored both esthetics and function of dental tissues and were expected to have physical properties comparable to those of tooth enamel and dentin. ^[10,11]

Although the efficiency of the material to be used in posterior areas has improved, it still encounters difficulty in building the proximal contacts and contours directly in the oral cavity. Despite significant improvements in their properties; occlusal wear, secondary caries, fracture, gap formation, and as a consequence, microleakage around composite restorations, remain the predominant concern for clinicians, especially in the posterior restorations. ^[10,12]

Table 1: Mean microleakage scores

	N	Median	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Group A	20	.0000	.5000	.68825	.15390	.1779	.8221
Group B	20	2.0000	1.8000	.61559	.13765	1.5119	2.0881
Group C	20	3.0000	2.4500	.68633	.15347	2.1288	2.7712
Negative Control	5	.0000	.0000	.00000	.00000	.0000	.0000
Positive Control	5	3.0000	3.0000	.00000	.00000	3.0000	3.0000

Mean microleakage scores in different study groups. Maximum mean microleakage was seen associated with positive control followed by Group C, Group B, and Group A.



Graph 1 shows the bar graph for the mean microleakage score at the gingival margin

Thus, taking into consideration the factors that can reduce the polymerization shrinkage thereby influencing the fracture resistance and microleakage of the restorative material, the present in-vitro study was conducted to evaluate Indirect composite (SR Nexco), Bulk fill composite (Tetric n Ceram), and Hybrid composite (TE Econom Plus) for microleakage in MOD cavities prepared on premolars; as they are subjected to a combination of compressive and shearing forces as a result of their functional role in mastication.

In this present study, MOD cavity design was prepared as it would weaken the remaining tooth structure and favor cuspal fracture. Also, maximum microleakage is seen at

gingival margins due to leakage of oral micro-organisms, fluids, and chemical substances through the gap at the tooth restoration interface.^[13]

Generally, microleakage has been evaluated using in-vitro models, with dye penetration as the most frequently used method. However, since new materials constantly appear, and considering clinical evaluations are time-consuming and expensive, in-vitro methods for microleakage are important tools in evaluating the possible performance of materials regarding sealing ability.^[3,14] Methylene blue was used as the disclosing agent in the present study because of its low molecular weight for dye penetration evaluation.

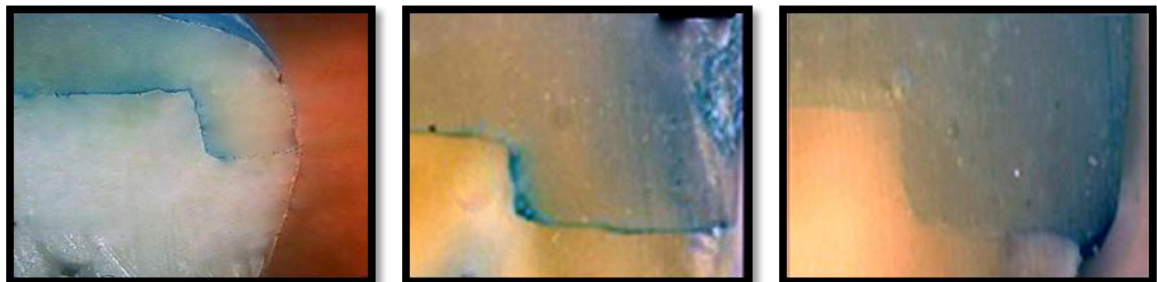
A thermocycling protocol was used to simulate the effects that restorative materials and adhesive systems are subjected

TABLE 2: Multiple comparisons

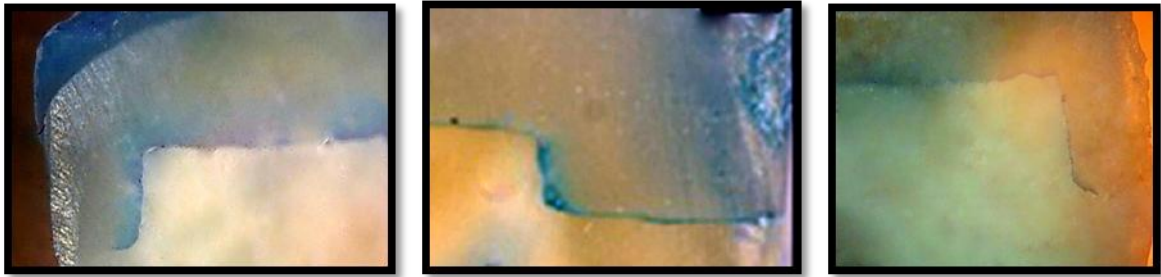
Group	Group	Mean Difference	P-value	95% Confidence Interval	
				Lower Bound	Upper Bound
Group A	Group B	-1.30000 ^{**}	<.001*	-1.8519	-.7481
Group A	Group C	-1.95000 ^{**}	<.001*	-2.5019	-1.3981
Group A	Negative Control	.50000	.097	-.3727	1.3727
Group A	Positive Control	-2.50000 ^{**}	<.001*	-3.3727	-1.6273
Group B	Group C	-.65000 ^{**}	.004*	-1.2019	-.0981
Group B	Negative Control	1.80000 ^{**}	<.001*	.9273	2.6727
Group B	Positive Control	-1.20000 ^{**}	.001*	-2.0727	-.3273
Group C	Negative Control	2.45000 ^{**}	<.001*	1.5773	3.3227
Group C	Positive Control	-.55000	.071	-1.4227	.3227
Negative Control	Positive Control	-3.00000 ^{**}	.003*	-4.1038	-1.8962



Figure 1: a) Dye penetration of samples of Group A (SR Nexco)



b) Dye penetration of samples of Group B (Tetric n Ceram bulk fill)



c) Dye penetration of samples of Group C (TE Econom plus)

to in the mouth, because of stresses at the adhesive interface generated by the difference in coefficients of thermal expansion between materials and dental structure.^[3,15]

The negative control group showed no microleakage as it consisted of intact teeth which were noncarious, without any craze lines or fracture lines while the positive control with mesio occlusal cavity without restoration showed the highest microleakage score.

According to the results of this study, Group A (SR Nexco) showed the lowest microleakage score of (0.5) followed by Group B (Tetric n Ceram bulk fill) which showed a mean microleakage score of (1.8) higher than Group A (0.5) followed by Group C (TE Econom plus) which had the highest score of (2.4) at the gingival margin ($P < 0.001$). This showed the least statistically significant value among all the groups ($P < 0.001$). This can be attributed to the fact that, when polymerization occurs indirectly, shrinkage is limited to the width of the luting space, which could reduce the deleterious effects at the interface.^[1] The production of restorations in a laboratory allows for appropriate proximal contours and contacts and control of the anatomic form. Also, post-curing with heat, pressure, and/or light increases the degree of conversion, thus improving the mechanical properties of the composite, resulting in better wear

resistance.^[5,16] The effect of post-curing heat has been studied by Cook and Johannson who showed an increase in diametral tensile strength, flexural strength, and fracture toughness of composites that were post cured at 100°C for 24 hours.^[17]

Most indirect composites differ from direct composites in the kind of indicator included in their composition; such materials designed for treatment with devices that employ heat can include thermosensitive initiators in addition to photosensitive initiators. Ferracane and Condon reported an increase in fracture toughness and modulus of elasticity of

composite after different post-curing light treatments. They also correlated the increase in the degree of conversion with the enhancement in mechanical properties. Relaxation of internal stresses at the filler-matrix interface is another outcome of post-cure heat treatment that may improve adhesion between resin matrix and fillers and improve the mechanical properties.^[19]

The stress generated during composite curing is influenced by both volumetric shrinkage and the modulus of elasticity of the composite. Tetric N Ceram bulk fill involves advanced composite filler technology, a pre-polymer shrinkage stress reliever (Ivocerin) a light initiator/polymerization booster, and a light sensitivity filter which because of its low elastic modulus acts as a spring & “holds on” to the cavity walls along with the matrix and the adhesive. Ultimately, the volumetric shrinkage and shrinkage stress are reduced during polymerization – allowing increments of up to 4 mm to be placed whilst ensuring a tight marginal seal.^[8,20]

One of the major advantages of the inlay technique is that polymerization shrinkage can be controlled and hence better marginal shrinkage can be expected than direct restorations.^[4] With the use of the inlay technique higher degree of cross-linking and stress relaxation can be obtained, since the application of light and heat may initiate new centers of polymerization. Inlays can be finished outside the mouth, hence inadequate contact areas can be improved before cementation.^[21,22] Stresses are placed on the tooth and the resin bond is reduced since the polymerization shrinkage occurs outside the mouth. Therefore, microleakage, post-operative sensitivity, and secondary caries will be reduced.^[4]

CONCLUSION:

Within the limitations of this in-vitro study following conclusion can be derived:

- Group A (SR Nexco composite) showed lesser microleakage compared to Group B (Tetric n Ceram bulk fill) and Group C (TE Econom plus).
- The best possible restoration for reinforcing the lost tooth structure in MOD preparation for better marginal adaptability was found to be Indirect / Lab composite (SR Nexco). However, other characteristics need to be investigated further.

This in vitro study needs to be carried out under ex in- Vivo conditions to analyze the best material under clinical conditions. Further studies with a large sample size are required to come to a definite conclusion.

REFERENCES:

1. **Duquia RCS, Osinaga PWR, Demarco FF, Habekost LV, Conceicao EN.** Cervical microleakage in MOD restorations: In vitro comparison of indirect and direct composite. *Oper Dent* 2006; 31(6):682-687.
2. **Lu PY, Chiang YC.** Restoring large defect of the posterior tooth by indirect composite technique: A case report. *Dent J* 2018; 6(54):1-7.
3. **Kidd EAM.** Microleakage: a review. *J Dent* 1976; 4(5):199-206.
4. **Kini A, Manjunatha M, Kumar S.** Comparison of microleakage evaluation of direct composite restoration and direct composite inlay system: An in-vitro study. *Int J Dent Clin* 2011; 3(3):31-33.
5. **Manhart J, Kunzelmann KH, Chen HY, Hickel R.** Mechanical properties of new composite restorative materials. *J Biomed Mater Res* 2000; 53: 353-361.
6. **Anusavice KJ.** Phillips' science of dental materials. WD Saunders 1996; Eleventh Edition: 426-428.
7. **Pilo R, Oelgiesser D, Cardash H.** A survey of output intensity and potential for depth of cure among light-curing units in clinical use. *J Dent* 1999; 27:235-259.
8. **Todd JC, Wanner M.** Scientific Documentation Tetric n Ceram Bulk fill Liechtenstein: Ivoclar Vivadent AG, Research and Development Scientific Service; 2012.
9. **Todd JC.** Scientific Documentation SR Nexco Paste, Liechtenstein: Ivoclar Vivadent AG, Research and Development Scientific Service; 2012.
10. **Wassell RW, Walls AWG, McCabe JF.** Direct composite inlays versus conventional composite restorations: 5 years follow-up. *J Dent* 2000; 28:375-382.
11. **Dhous S, Jabrane K, Talache N, Lahlou K, Ouazzani A, Merini H.** Indirect posterior restoration: composite inlays. *Biomed J Sci Tech Res* 2018; 5(1):4312-4316.
12. **Uludag B, Ozturk O, Ozturk AN.** Microleakage of ceramic inlays luted with different resin cement and dentin adhesives. *J Prosthet Dent* 2009; 102:235-241.
13. **Lopes LM, Leitao JG, Douglas WH.** Effect of a new resin inlay/onlay restorative material on cusp reinforcement. *Quintessence Int* 1991; 22(8):641-5.
14. **Raskin A, Tassery H, D'hoore W, Gonthier S, Vreven J.** Influence of the number of specimens on the reliability of in vitro microleakage evaluations. *Am J Dent* 2003; 6: 207-210.
15. **Cehreli ZC, Gungor HC.** Quantitative microleakage evaluation of fissure sealants applied with or without a bonding agent: results after four-year water storage in vitro. *J Adhes Dent* 2008; 10: 379-384.
16. **Mota CS, Demarco FF, Camacho GB & Powers JM.** Microleakage in ceramic inlays luted with different resin cement. *J Adhes Dent* 2003;5(1) 63-70.
17. **Cook WD, Johannson M.** The influence of post-curing on the fracture properties of photo-cured dimethacrylate based dental composite resin. *J Biomed Mater Res* 1987;21(8):979-89.
18. **Verónica A. Almeida-Chetti, Ricardo L. Macchi, María E. Iglesias.** Effect of post curing treatment on mechanical properties of composite resins. *Acta Odontol Latinoam* 2014;27(2):72-76.
19. **Ferracane JL, Condon JR.** Post-cure heat treatments for composites: properties and fractography. *Dent Mater* 1992;8(5):290-5.
20. **Eltoum NA, Bakry NS, Talaat DM, Elshabrawy SM.** Microleakage evaluation of bulk-fill composite in class II restorations. *Alex Dent J* 2019;44:111-116.
21. **Dionysopoulos P, Watts DC.** Dynamic mechanical properties of an inlay composite. *J Dent* 1989; 17: 140-144.
22. **Dijken JWV, Hijrstedt P.** Marginal breakdown of 5-year-old direct composite inlays. *J Dent* 1996; 24: 389-394.