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Noncarious Cervical Lesions Restored with Three Different Tooth-Colored Materials: Two-Year Results

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Clinical Relevance

Microfilled composite, nanohybrid composite, and compomer give similar results in treatment of noncarious cervical lesions within a two-year evaluation period.

SUMMARY

Introduction: **The aim of this two-year prospective clinical study was to evaluate and compare the clinical performance of three different adhesive esthetic materials in noncarious cervical lesions.**

Material and Methods: **A total of 90 restorations (30 per material) were placed in 30 patients who ranged in age between 18 and 50 years and of both genders, by a single operator with no previous preparation. The restoration of noncarious cervical lesions was done with either a microfilled composite (Esthet.X/Dentsply/De Trey, Konstanz, Germany, and Prime&Bond NT/Dentsply/De Trey), a nanohybrid composite (TetricEvoCeram/Vivadent, Schaan, Liechtenstein, and AdheSE/Vivadent), or a compomer (Dyract eXtra/Dentsply/De Trey and Xeno III Dentsply/De Trey). All restorations were evaluated by independent examiners using a modified US Public Health Service criteria at baseline and after 12 and 24 months for six clinical categories. Data were analyzed statistically by Pearson's chi-**

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square or the Fisher's exact test at 5% significance level ($p<0.05$).

Results: **Results showed that most of the restorations were clinically satisfactory after 12 and 24 months, with no statistically significant differences among the three groups for all evaluated criteria.**

Conclusion: **Treatment of noncarious cervical lesions using composite and compomer materials, combined with the appropriate adhesive systems and properly implemented restorative procedures, gives satisfactory results after a two-year evaluation period.**

INTRODUCTION

Noncarious cervical lesions (NCCLs) represent irreversible loss of hard tooth tissue in the cervical zone of teeth. They may have different forms, from shallow to deep and huge wedge-shaped defects that may be flat, concave, or acute angled. NCCLs are initially located in enamel; however, they progress slowly into the dentin and gradually lead to dentinal sclerosis. Dentinal sclerosis is formed as a response to low-intensity chronic stimuli and as the consequence of physiological aging, consistent with the fact that NCCLs occur more in the older population. However, there is also a high prevalence of noncarious cervical lesions that affect children and adolescents.[1]

If the occurrence of NCCLs is more progressive, these lesions show a marked hypersensitivity, causing discomfort to the patient; this situation lasts until the dentinal tubules are closed. When these lesions become sclerotic from mineral deposits that occlude the dentin tubules, the tooth becomes insensitive to stimuli.[2–4]

In the treatment of NCCLs, clinicians most commonly use composites, glass-ionomer cements, or a combination of two restorative materials with the appropriate adhesive systems. Micromechanical retention, preserving tooth structure, good esthetics, and functional features are all aspects when making the choice of material. Esthetic materials and adhesive systems are constantly being improved in order to enhance adhesion to hard dental tissues, improve esthetic features, reduce polymerization contraction, and simplify the clinical procedures. To get a good bond between the adhesive and dental structures, it is necessary that the enamel and dentin surfaces are appropriately prepared, the adhesive system has a low viscosity, and the treated surface has a low surface tension.[5,6]

The conditioning of dentin significantly affects the quality of adhesive bonding. For the successful restoration of NCCLs, it is necessary to possess a good knowledge of micromorphological characteristics of the sclerotic dentin, which is the basic bonding substrate with the restorative material. Sclerotic, or vitreous dentin, is shiny and dark with a homogenic surface, is considerably tougher when probing, and contains denatured collagen, which significantly hinders the formation of adhesive interlocking.[7,8] The literature shows that the quality of adhesion to sclerotic dentin is weaker when compared to nonsclerotic dentin, as the conditioning of sclerotic dentin is unpredictable because of the higher degree of mineralization and almost complete obliteration of the dentinal tubules, resulting in a lower penetration of adhesives.[8,9] The hybrid layer (resin-reinforced dentin zone) is significantly thinner in sclerotic dentin when compared with normal dentin.[3,9]

The frequent localization of NCCL margins in cementum and/or dentin makes their treatment more difficult, thus making the cervical restoration margins more susceptible to microleakage. The flow of microorganisms and oral fluid due to microleakage may cause marginal discoloration of restorations, postoperative sensitivity, secondary caries, and irreversible pulp disease.[6,7,9]

The aim of this two-year prospective clinical study was to investigate the clinical performance of adhesive esthetic materials for dental restorations in the treatment of NCCLs using modified US Public Health Service (USPHS) criteria.

MATERIALS AND METHODS

The Selection of Patients and Teeth for Restoration

This prospective clinical study lasted 24 months, during which the clinical evaluation of the treatment of NCCLs with different esthetic materials was carried out. The study included 30 patients, aged between 18 and 50 years, and of both sexes. After getting familiar with the type and purpose of the study, the respondents gave their written consent for their participation. The protocol of tests and written consent of the patients were reviewed and approved by the Ethics Committee of the Medical Faculty Novi Sad.

The criteria for inclusion of patients in the study, along with the clinical diagnosis of noncarious cervical lesions, were satisfactory oral hygiene, low caries index, preserved vitality of teeth, and the

absence of periodontitis, periradicular lesions, traumatic occlusion, bruxism, and wear facets, whereas the criteria for excluding patients from the study were anamnestic data indicating pulp pathology of teeth scheduled for inclusion in the study, diagnosed caries with cervical defects, and patients with mobile or fixed prosthetic restorations in the immediate environment of the tooth restorations to be observed in the study.

A detailed dental history was taken from all patients, along with an oral examination, recording the dental and periodontal status, occlusal relationships, movements of the lower jaw, and temporomandibular joint examination.

The final sample consisted of 30 patients, 90 teeth with NCCLs that had a minimum depth of 1 mm, and each patient obtained at least two different restorations and no more than three restorations of the same material, which is in accordance with the recommendations of the American Dental Association on testing adhesive restorative materials in clinical trials.[10]

After the formation of the sample, according to the above-mentioned criteria, there was an additional division of the subjects into three groups, depending on the materials used in the treatment of NCCLs.

The study used the following materials and adhesive systems:

1. Microfilled composite Esthet.X (Dentsply/De Trey, Konstanz, Germany) with a two-step etch & rinse adhesive system, Prime&Bond NT (Dentsply/De Trey), hereinafter EstX-P&B.
2. Nanohybrid composite TetricEvoCeram (Vivadent, Schaan, Liechtenstein) with a two-component two-step self-etching adhesive system, AdheSE (Vivadent), hereinafter TeC-AdSE.
3. Compomer Dyract eXtra (Dentsply/De Trey) with a two-component one-step self-etching adhesive system, Xeno III (Dentsply/De Trey), hereinafter DyeX-XeIII.

Clinical Protocol of NCCL Restoration

Immediately before the restorative procedures, the color of of the teeth to be restored was determined because of the subsequent dehydration of dental tissue and changes of the optical properties of enamel during treatment. The surfaces of the NCCLs were mechanically cleaned with a rotating brush and prophylactic paste without fluoride (Nupro Cups without fluoride, Dentsply/De Trey). It is imortant to emphasize that the lesions were not prepared with any cutting instruments, following the guidelines of the American Dental Association Acceptance program for dentin and enamel adhesive materials, which do not allow the placement of bevels.[10] Isolation was achieved using a cheek retractor, cotton rolls, a saliva ejector, and retraction cord (Ultrapak knitted retraction cord # 1, Ultradent Inc., South Jordan, UT) placed in the gingival sulcus of the treated tooth.

The cavities were restored in accordance with the manufacturer's instructions for each tested material as follows:

1. EstX-P&B. Enamel and dentin surfaces were treated with 36% orthophosphoric acid (DeTrey Conditioner 36 Conditioning & Etching Gel, Dentsply/De Trey) for 20 and 10 seconds, respectively. The cavity was rinsed with water spray for 20 seconds and then dried slightly, taking care to avoid overdrying the dentin. The adhesive system (Prime&Bond NT, Dentsply/De Trey) was applied to the conditioned surface of the cavity using the applicator for 20 seconds, slightly dried, and light polymerized using a SmartLite PS Pen-Style High-Power LED Curing Light (Dentsply/De Trey) for 10 seconds. The composite, Esthet.X (Dentsply/De Trey), was placed into the cavity in two layers, and each layer was polymerized for 20 seconds with the same light source.
2. TeC-AdSE. The surface of each NCCL was first treated with AdheSE Primer (Vivadent) 30 seconds, using the applicator. Excess primer was dried with an air spray until the liquid film on the cavity surface was no longer visible. A thin layer of AdheSE Bond (Vivadent) was applied to the entire dentin and was light polymerized (SmartLite PS Pen-Style High-Power LED Curing Light, Dentsply/De Trey) for 10 seconds. The composite, TetricEvoCeram (Vivadent), was placed in the cavity in two layers, with each layer polymerized for 20 seconds with the same light source.
3. DyeX-XeIII. The adhesive system, Xeno III (Dentsply/De Trey), was previously prepared by mixing liquid A and liquid B in a separate mixing bowl for 5 seconds and then applied to the prepared cavity surface (not overdried). After 20 seconds, it was gently dried by an air spray and polymerized with the SmartLite PS Pen-Style High-Power LED Curing Light (Dentsply/De Trey) for 10 seconds. Dyract eXtra (Dentsply/De Trey) was placed in the cavity in two layers, with each layer polymerized for 20 seconds with the same light source.

Table 1: *Modified USPHS criteria for six clinical categories*

Category	Grade	Criterion
Retention	Alpha (A)	Retained
	Charlie (C)	Partially retained or missing
Marginal integrity	Alpha (A)	Closely adapted, no visible crevice
	Bravo (B)	Visible crevice, explorer will penetrate
	Charlie (C)	Crevice in which dentin is exposed
Marginal discoloration	Alpha (A)	No discoloration
	Bravo (B)	Superficial staining (without axial penetration)
	Charlie (C)	Deep staining (with axial penetration)
Wear	Alpha (A)	Continuous
	Bravo (B)	Discontinuous, no dentin exposed
	Charlie (C)	Discontinuous, dentin exposed
Postoperative sensitivity	Alpha (A)	None
	Charlie (C)	Present
Recurrent caries	Alpha (A)	No caries present
	Charlie (C)	Caries present

The removal of excess material and finishing of the restoration was carried out using diamond burs of different grain fineness, in a dry working area for better visibility and accuracy in order not to damage the enamel. Polishing was done after seven days with the Enhance Finishing and Polishing System (Dentsply/De Trey).

Clinical Evaluation

The operator who placed the restorations did not take part in the clinical evaluation of the test results. That part was carried out by operators who were not familiar with the materials used in restoring the NCCLs, thus forming a double-blind study. All of the restorations were recorded with a digital camera (Nikon Digital Camera D 3000, Nikon Corp., Tokyo, Japan) at each examination. The evaluation of results was done using the modified USPHS criteria (Table 1), and the following were evaluated: retention (R), marginal integrity (MI), marginal discoloration (MD), wear (W), postoperative sensitivity (PS), and secondary caries (SC). The rating A (Alpha) was used to mark the best quality restorations, B (Bravo) minor change, and C (Charlie) an unsatisfactory quality of the restoration. To record the findings, forms were used to include the following: patient's name, the tooth on which the restoration was placed, and the criteria for assessing the quality of the restorations. The forms were completed immediately after finishing the restorations and at clinical evaluations after 12 and 24 months.

The statistical analysis of each criterion among the tested materials was performed using Pearson's chi-square or the Fisher's exact test at a 5% significance level ($p<0.05$).

RESULTS

At baseline, all ratings were 100% Alpha. Recall examinations for all the patients were performed after 12 and 24 months. The results are shown in Table 2.

For *retention rate* after 24 months, there was a loss of six (20%) EstX-P&B, five (16.7%) TeC-AdSE, and five (16.7%) DyeX-XeIII restorations. Regarding *marginal integrity* after 24 months, there were seven (29.2%) EstX-P&B, 10 (40%) TeC-AdSE, and six (24%) DyeX-XeIII restorations that were evaluated Bravo (visible cracks, with no exposed dentin). Charlie ratings (cracks with exposed dentin) were given to four (16.7%) EstX-P&B, five (20%) TeC-AdSE, and two (8%) DyeX-XeIII restorations.

Regarding *marginal discoloration* after 24 months, Bravo ratings (surface discoloration with no axial penetration) were given to six (25%) EstX-P&B, 10 (40%) TeC-AdSE, and seven (28%) DyeX-XeIII restorations. Ratings of Charlie (deep discoloration of the axial penetration) were not observed in any of the restorations placed.

A Bravo rating (discontinuous wear without dentin exposure), for *wear* after 24 months, was given to two (8.3%) EstX-P&B, four (16%) TeC-AdSE, and two (8%) DyeX-Xe III restorations. Charlie ratings (discontinuous wear with dentin exposure time) were not recorded in any of the restorations placed at the end of the evaluation period.

Table 2: *Clinical analysis of restorations of cervical lesions after 12 and 24 months results (cont.)*

Category	Material	After 12 Months			After 24 Months		
		A	B	C	A	B	C
Retention	EstX-P&B	28[a] (93.3)[b]	0	2[a] (6.7) [b]	24[a] (80.0)[b]	0	6[a] (20.0)[b]
	TeC-AdSE	28[a] (93.3)[b]	0	2[a] (6.7)[b]	25[a] (83.3)[b]	0	5[a] (16.7)[b]
	DyeX-Xe III	28[a] (93.3)[b]	0	2[a] (6.7)[b]	25[a] (83.3)[b]	0	5[a] (16.7)[b]
			Fisher, p=1			Fisher, p=0.927	
Marginal integrity	EstX-P&B	21[a] (75.0)[b]	5[a] (17.9)[b]	2[a] (7.1)[b]	13[a] (54.2)[b]	7[a] (29.2)[b]	4[a] (16.7)[b]
	TeC-AdSE	18[a] (64.3)[b]	8[a] (28.6)[b]	2[a] (7.1)[b]	10[a] (40.0)[b]	10[a] (40.0)[b]	5[a] (20.0)[b]
	DyeX-Xe III	25[a] (89.3)[b]	3[a] (10.7)[b]	0	17[a] (68.0)[b]	6[a] (24.0)[b]	2[a] (8.0)[b]
			Fisher, p=0.237			Fisher, p=0.383	
			Chi^2=5.53			Chi^2=4.17	
Marginal discoloration	EstX-P&B	25[a] (89.3) [b]	3[a] (10.7)[b]	0	18[a] (75.0)[b]	6[a] (25.0)[b]	0
	TeC-AdSE	22[a] (78.6)[b]	6[a] (21.4)[b]	0	15[a] (60.0)[b]	10[a] (40.0)[b]	0
	DyeX-Xe III	23[a] (82.1)[b]	5[a] (17.9)[b]	0	18[a] (72.0)[b]	7[a] (28.0)[b]	0
			Fisher, p=0.548			Fisher, p=0.484	
	EstX-P&B	27[a] (96.4)[b]	1[a] (3.6)[b]	0	22[a] (91.7)[b]	2[a] (8.3)[b]	0
Wear	TeC-AdSE	25[a] (89.3)[b]	3[a] (10.7)[b]	0	21[a] (84.0)[b]	4[a] (16.0)[b]	0
	DyeX-Xe III	27[a] (96.4)[b]	1[a] (3.6)[b]	0	23[a] (92.0)[b]	2[a] (8.0)[b]	0
			Fisher, p=0.427			Fisher, p=0.588	
Postoperative sensitivity	EstX-P&B	23[a] (82.1)[b]	0	5[a] (17.9)[b]	24[a] (100)[b]	0	0
	TeC-AdSE	26[a] (92.9)[b]	0	2[a] (7.1)[b]	25[a] (100)[b]	0	0
	DyeX-Xe III	27[a] (96.4)[b]	0	1[a] (3.6)[b]	25[a] (100)[b]	0	0
			Fisher, p=0.166			Fisher, p=1	

After 12 months, *postoperative sensitivity* was present (grade Charlie) in five (17.9%) EstX-P&B, two (7.1%) TeC-AdSE, and one (3.6%) of the DyeX-Xe III restorations. After 24 months, there was a complete regression of postoperative sensitivity (rating change from Charlie to Alpha). *Secondary caries* was not registered in any restoration after the two-year evaluation period. When comparing the

Table 2: *Continued*

Category	Material	After 12 Months			After 24 Months		
		A	B	C	A	B	C
Recurrent caries	*EstX-P&B*	28[a] (100)[b]	0	0	24[a] (100)[b]	0	0
	TeC-AdSE	28[a] (100)[b]	0	0	25[a] (100)[b]	0	0
	DyeX-Xe III	28[a] (100)[b]	0	0	25[a] (100)[b]	0	0
		Fisher, p=1			Fisher, p=1		

Abbreviations: A, Alpha; B, Bravo; C, Charlie; EstX-P&B, Esthet.X + Prime&Bond NT; TeC AdSE, TetricEvoCeram + AdheSE; DyeX-Xe III, Dyract eXtra + Xeno III; Fisher, Fisher exact test; Chi^2, Pearson chi-square test.
[a] The values denote the number of restorations receiving respective scores for each criterion.
[b] Figures in parentheses indicate percentages.

results obtained after 12 and 24 months, no statistically significant differences in any of the criteria among the groups were noticed.

DISCUSSION

Unclear etiology, pathogenesis, diagnosis, and selection of restorative procedures for NCCLs represent a major problem in dentistry and a frequent subject of discussion, as there are still many doubts and contradictions. NCCLs are also a challenge for every clinician because of the difficulties in their restoration.[3]

There are many studies analyzing the *in vitro* behavior of materials while simulating the optimal oral environment. Laboratory tests, although easier, quicker, and more convenient, cannot replace clinical studies, nor can they predict the clinical performance of restorative materials *in vivo*. Therefore, clinical studies are the most reliable when it comes to drawing conclusions about the quality of restorative materials.[11,12] Rapid technological developments and the emergence of new materials on the market, as well as the time required for clinical trials and publication of the results, have significantly reduced the number of published clinical studies dealing with the quality of restorative materials. Likewise, there is an overt tendency to shorten the *in vivo* evaluation period to one year, although observance for an extended period of time is more desirable.[4]

Various tests are used to assess the quality of materials for final restorations, such as the Ryge protocol, the CDA system, and modified USPHS criteria. Modified USPHS criteria are widely accepted and are suitable for a long-term clinical evaluation of restorations and also for comparing the results of different studies.[13] The fault with the modified USPHS criteria, as stated by Hayashi and Wilson, is a frequent overlap of Alpha with Bravo ratings for criteria, such as marginal integrity, marginal discoloration, and restoration wear. The assessment criteria should be better standardized to provide better uniformity of examiners and reliable results; until then, they should be treated cautiously.[14]

Since NCCLs do not have a retentive shape and are not prepared, they represent an appropriate model for testing adhesion of materials to dental tissue. Most researchers use this feature, and today many studies are drawing conclusions about the adhesive properties of materials precisely by examining them on NCCLs.[5,15]

In the current two-year clinical study, with a sample size of 30 subjects, the number (30 for each esthetic restorative material) and distribution of restorations were in accordance with the recommendations of the American Dental Association regarding the clinical examinations of restorative materials.[10]

The retention of restorations is the key criterion by which clinical efficacy of the applied adhesive systems and restorative materials are estimated. This is the most reliable diagnostic criterion and the most obvious sign of a failed restoration since it does not depend on the examiner's subjective assessment.[13]

In the present study, the retention rate after the two-year evaluation period was not statistically

significant from the 12-month evaluation and was between 80% and 83.3% depending on the material. Pollington,[16] while examining composites (Pertac-II) and compomers (Hytac) in combination with a self-etching adhesive system (Prompt L-Pop) placed on NCCLs, obtained a retention rate of 86.6% for the composite and 86.7% for compomers after 36 months. In a one-year clinical study, Burrow and Tyas[17] tested the single-phase two-component adhesive One-Up Bond F, which belongs to the all-in-one adhesive group, in combination with the composite material Palfique Estelite for restoring NCCLs. At the end of their evaluation period, the retention rate was 100%, which is a tremendous deviation from the results of a similar clinical study that tested a similar single-phase two-component adhesive system (Prompt L-Pop, 3M-ESPE, St Paul, MN, USA) where after one year the retention rate was 65%.[18] It is difficult to compare the durability of the restoration of NCCLs with other clinical studies since many factors affect the retention of restorations. The differences in the obtained results can be attributed to differences in the morphology of the cavity, variability, and operator skill; type of occlusion; binding capacity of the restorative system; and the polymerization of the restorative materials.[11,16,18] As a patient ages, dentin becomes more sclerotic, the frequency of NCCLs is higher, and the retention of restorations is decreasing, as shown by Bayne and others.[19] Those authors found that the percentage of the loss of restorations in patients aged 21–40, 41–60, and 61–80 was 31%, 62%, and 75%, respectively.[19] Baratieri and others[20] examined the effect of enamel beveling on the retention of Class V composite restorations. After a three-year clinical evaluation, those authors concluded that beveled margins did not contribute to increased retention rates. Beveling the enamel as a way of improving retention is incompatible with the concept of maximum preservation of tooth structure and preventing further structure loss, which is the basis of contemporary dentistry.[5,21]

The occurrence of inadequate marginal adaptation (ie, the existence of marginal defects) is a sign of degradation of adhesive bonding that leads to the clinical failure of restorations.[21] Polymerization contraction, a different coefficient of thermal expansion between the material, and dental structure and occlusal loading are all potential causes of marginal cracks.[7,21] The quality of marginal attachment depends largely on the type of adhesive system; the physical, mechanical, and viscoelastic properties of materials; and the techniques of restoration. While examining adhesive systems in their extensive one-year clinical study, Van Merbeek and others[22] indicated that failure in all tested adhesive systems showed inadequate margin closure. The differences among results in the literature are largely the consequence of the lack of universal criteria in evaluation, but there is also the possibility of errors during the sensitive restorative procedures. The violation of the marginal integrity may be the result of inadequate finishing and polishing, dimension changes during the polymerization, and/or absorption of water as well as the hygroscopic expansion of the glass-ion components of restorations.[7,21]

The occurrence of marginal discoloration is closely associated with the formation of marginal defects. In the current study, after a two-year evaluation period, the percentage of marginal discoloration and Bravo ratings (surface discoloration with no axial penetration) was higher in group 2 (TeC-AdSE) at 40%, while the restorations in groups 1 (EstX-P&B) and 3 (DyeX-Xe III) presented Bravo ratings of 25% and 28%, respectively. Approximately 70% of the marginal discoloration presented on the mesial and distal margins of the restorations, which are difficult to reach in order to finish the restorations correctly. This leads to the conclusion that marginal discoloration is more likely caused by the accumulation of pigments on the retained steps or cracks than by microleakage.[23,24] In a very large clinical study, Di Lenarda and others[25] examined the marginal discoloration of esthetic restorations. After 48 months, they observed discolouration in 40% of the cervical restorations that were placed without etching the enamel, whereas this change was noticed in 16.7% of the restorations in cases when the total etching technique of enamel was applied, which represents a statistically significant difference between the two studied groups. The above-mentioned phenomenon is associated with inferior adhesive bonding of single-phase self-etching adhesive systems and enamel regarding the conventional three-phase adhesive means.[26] The wear criterion had no statistical significance in the current study.

In the present study, postoperative tooth sensitivity, which was present after 12 months, fully withdrew after two years. Perdigao and others[27] found that the increased sensitivity at the beginning of the evaluation results from retraction of the gingiva and tooth root surface exposure, which occurs immediately after placing a restoration or after its finishing and polishing. Sensitivity that was created immediately after placement of the restoration may be the result of mechanical damage of the

gingiva during finishing and polishing or excess material that was left in contact with soft tissues. Gingivitis will be reversible if the surface of the restoration is well polished, without the existence of steps and uneven parts.

After a two-year evaluation period, secondary caries did not occur in any of the three tested groups. Patients with NCCLs are usually characterized by a low caries index and good oral hygiene, especially after remotivation and training that was performed prior to the restorative procedures; this can explain the absence of secondary caries in this current study.

CONCLUSION

After a two-year evaluation period, no statistically significant differences were observed in any of the criteria of the surveyed group of adhesive esthetic materials. Restoration of NCCLs can be carried out in a satisfying manner using composite and compomer materials in combination with the appropriate adhesive system and appropriate restorative procedures. In addition to the proper selection of restorative materials, the elimination of etiological factors, occlusal balance, and good oral hygiene are also important factors for the longevity and quality of restorations.

Conflict of Interest Declaration

The authors of this manuscript certify that they have no proprietary, financial or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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