Clinical outcomes of zirconia-reinforced lithium silicate partial coverage crowns compared to lithium disilicate partial coverage crowns. A randomized controlled split-mouth clinical study [version 1; peer review: 1 approved, 1 not approved]

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Abstract

**Background:** Despite the fact that preliminary clinical results of conservative partial coverage restorations (PCRs) are promising, the clinical behavior of different PCR ceramic materials is rarely investigated in clinical trials. This study aimed to evaluate the clinical outcomes of partial coverage restorations (PCR) fabricated with zirconia-reinforced lithium silicate ceramic system compared to partial coverage restorations fabricated with lithium disilicate ceramic system.

**Methods:** 46 vital premolars and molars of 14 patients were restored with PCRs (23 Vita Suprinity and 23 IPS e.max CAD). PCRs were CAD/CAM fabricated in the lab and adhesively luted with dual-polymerizing resin cement (Duolink. BISCO, USA). Clinical evaluation of PCRs was performed according to the Modified United States Public Health Service (USPHS) at baseline, 6 and 12 months post-insertion. Absolute failure was demonstrated by Kaplan-Meier survival rate analysis.

**Results:** After 12 months observation, all PCRs of both ceramic groups demonstrated 100% survival rate. Non-significant decrease in Alpha ratings for marginal adaptation (p = 0.1560) and marginal discoloration (p = 0.6078) in e-max group. While in the Suprinity group, PCRs demonstrated 100% Alpha ratings for marginal adaptation and only one Bravo rating (p= 0.3625) for marginal discoloration after 12 month observation.

**Conclusions:** Both Vita-Suprinity and e.max CAD partial coverage restorations are considered reliable treatment options for restoring larger defects in posterior dentition.

**Trial registration:** ClinicalTrials.gov NCT02861729 04/08/2016
Keywords
Partial coverage restorations, posterior teeth, ceramic, Zirconia reinforced lithium silicate, lithium disilicate, CAD/CAM

Corresponding author: Hanaa Nassar (dr.h.nassar03@gmail.com)

Author roles: Nassar H: Conceptualization, Funding Acquisition, Investigation, Methodology, Project Administration, Visualization, Writing – Original Draft Preparation; H Halim C: Formal Analysis, Software, Supervision, Visualization; A Katamish H: Data Curation, Resources, Supervision, Validation, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

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Introduction
High survival rates, fracture resistance and proper marginal integrity of CAD/CAM partial coverage restorations (PCRs) were reported in studies simulating 5-year clinical service.[1-4]

However, clinical behavior of PCRs utilizing morphology driven preparation design was never assessed in randomized clinical trials.[5-11]

Furthermore, long-term clinical studies have shown that bulk fracture and marginal deterioration of PCRs has a direct correlation to the use of brittle ceramic materials, such as feldspatic and leucite-based ceramics,[12-15] which encouraged researchers to use higher strength lithium disilicate glass ceramic in such restorations.[16-21] Although some clinical studies tested the performance of lithium disilicate PCRs, no randomized clinical trial tried to compare between lithium disilicate ceramic material and the newly introduced zirconia-reinforced lithium silicate ceramic material in posterior partial coverage.[22-24]

The aim of this randomized controlled split-mouth clinical study was to evaluate the clinical outcomes of zirconia-reinforced lithium silicate (Vita Suprinity) and lithium disilicate (IPS e.max CAD) partial coverage restorations. The null hypothesis was that there would be no difference between the two ceramic materials over 12 months.

Methods
Ethical considerations and consent
This study was approved by Ethics Committee of Faculty of Oral and Dental Medicine in October 2016 (Approval number: 03102016).

Written informed consent for all the study procedural steps and publication of their clinical results and images were obtained from the patients.

This trial was registered with ClinicalTrials.gov under trial number NCT02861729 on the 04/08/2016.

Study design
This study was a double blinded, split-mouth randomized controlled clinical trial, with an allocation ratio of 1:1.

This article was written in concordance with the CONSORT checklist 2010 (see Reporting guidelines).

Participants
All patients were recruited from the outpatient clinic of the Department of Fixed Prosthodontics, Faculty of Oral and Dental Medicine, Cairo University, Cairo, Egypt. Between May 2017 and June 2017, a total of 14 adult patients (8 females and 6 males) were included in this study after fulfilling all inclusion criteria. A total of 46 premolars and molars (20 maxillary and 26 mandibular) were restored in this study, according to split-mouth design; at least two restorations (one of each ceramic material) were placed in each patient.

Inclusion criteria:
Adult patient aged 18-50 years old. Patient with good oral hygiene (papillary bleeding index (PBI < 35%).

Teeth: vital, with large carious lesions/defective restorations and teeth in occlusion.

Exclusion criteria:
Patient with severe systemic disorder, smokers, xerostomia or buxism

Teeth: non-vital, endodontically treated, mobile or periodontally affected teeth.

Sample size
Based on the previous paper by Guess et al. 2009,[15] the probability of surface roughness among interventions is 0.48. If the true probability among controls is 0.11, it was estimated that a total of 46 samples (n= 23 of each ceramic material group) would be required to reject the null hypothesis that the exposure rates for case and controls are equal with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05. Sample size was calculated using G* Power program, version 3.0.10.

Randomization
A random sequence was generated by computer software (http://www.randomizer.org/ ) in the Center of Evidence Based Dentistry, Cairo University. The table was kept with the assistant supervisor (CHH). Participants received numbered papers each contains a number from 1 to 2 representing ceramic material and a letter R or L representing the side where PCR will be placed on folded paper placed in sealed opaque envelopes. The patient selected the ceramic material for the first tooth randomly, and then the following tooth received the alternate ceramic material according to the split-mouth design.

Interventions
All clinical steps were performed by one operator (HN) and laboratory steps by one technician.

First visit (teeth preparation)
A new cavity preparation design; morphology driven preparation (MDP) design was selected for this study. In this design, preparations were guided by the anatomical and structural morphology of the teeth.[25-27]

Interior walls were prepared with 6–10° divergence, well-defined margins and rounded inside angles. Inter-proximal box was prepared with 1–1.2mm butt-joint, all obtained with medium-grit 80μm diamond truncated conical bur (4137-856-025, Microdont, USA). (Figure 1)

Occlusal reduction of 1.5–2mm was performed with egg-shaped football bur (3118-368-023, Microdont, USA), and verified with silicon index. The outer axial walls with inclined planes were prepared with hollow chamfer margin obtained with round bur (1014-801-014, Microdont, USA). (Figure 2)
Final PCRs were designed using CAD/CAM software (Exocad-DentalCAD, Exocad GmbH-Slovenia) and milled with 5-axis machine (CAM5-S1impression.Vhf, Ammerbuch-Germany) of Suprinity (VITA-ZahnfabrikH. Rauter-GmbH-Germany, Catalogue no.: 2002E – 0114 (X.) S Version (02)) and e.maxCAD (Ivoclar-Vivadent, Schaan-Liechtenstein, Catalogue no.: 721198/e/2018-11) blocks. After staining, PCRs crystalization was done in ceramic furnace (Programat-P310) according to manufacturer instructions.

**Second visit (PCRs try-in and bonding)**

Definitive PCR try-in was performed to confirm the restoration proper seating, marginal integrity, shade matching and proper occlusal and proximal contacts.

All PCRs bonding steps were performed under rubber-dam isolation.

The internal surfaces of PCRs were etched for 20 second with 9.5% hydrofluoric acid (BISCO-USA, Catalogue no.: E-5702EP), rinsed, air dried, then Bis-silane (BISCO-USA, Catalogue no.: B-2221P) was applied, left for 60 seconds and air dried.

Enamel margins of the preparations were etched with 37% phosphoric acid (BISCO-USA) for 30 seconds, rinsed and air dried. All-bond universal adhesive was applied, air thinned, and cured for 20 seconds (Elipar™, 3MESPE, USA, Catalogue no.: 70-2013-0430-3-B). Duolink adhesive resin cement (BISCO-USA, Catalogue no: A-19010P), was applied to fitting surface; restoration was seated with gentle pressure, glycerin barrier was applied to margins (Deox.Ultradent-USA, Catalogue no: 238), then light curing was performed for 40 seconds (Elipar™, 3MESPE, USA, Catalogue no.: 70-2013-0430-3-B).

Residual cement was removed and occlusion was carefully checked.

### Clinical evaluation

The PCRs were assessed for clinical outcomes by an independent outcome assessors according to the modified United States Public Health Service (USPHS) criteria\(^ {28-30}\); at baseline, 6 and 12 months post-treatment. PCRs were visually inspected with mirror, probe and dental floss; all changes were recorded and photographed\(^ {31}\).

#### Primary outcome: survival rate

For survival rate, only Alpha ratings were considered success.

Absolute failure was defined by loss of retention, fracture, crack development which required a replacement of the entire restoration, secondary caries or endodontic complications\(^ {32-35}\) (Table 1).

#### Secondary outcomes: marginal adaptation and marginal discoloration

Alpha and Bravo scores were considered success, while PCRs rated Charlie or Delta were considered failure\(^ {15,16,32,35}\).
Discussion
This study aimed to compare the clinical performance of Vita Suprinity and e-max CAD partial coverage restorations in a prospective double-blinded split-mouth design. Selection biases can be avoided in split-mouth studies as the patient acts as their own control, in this way direct comparison of two ceramic materials can be performed.

Compared to full coverage restorations, posterior partial coverage restoration utilizing more tooth structure conservation concept has the potential to reinforce and protect tooth structure.

Blinding
This study was a double-blinded study; both patient and outcomes’ assessors were blind to the assigned PCR material for each tooth throughout all preparation and clinical evaluation steps. However, the operator wasn’t blinded for purpose of lab communication and ceramic material construction steps.

The blinded assessors were asked to fill a chart for each outcome with the number corresponding to each patient without knowing the PCR material allocated to each side of the mouth for each participant. The template for clinical assessment chart can be found with the trial protocol (Extended data).

![Kaplan Meier Survival Curve for two tested groups.](image)

### Table 1. Kaplan-Meier estimate for survival.

<table>
<thead>
<tr>
<th>Kaplan-Meier estimate</th>
<th>Median survival time (Vita Suprinity)</th>
<th>Median survival time (IPS e.max CAD)</th>
<th>Confidence interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 50% survival</td>
<td>&gt; 50% survival</td>
<td>0.4045 - 2.0774</td>
<td>0.8254</td>
</tr>
</tbody>
</table>

For criteria marginal adaptation, e-max CAD group showed a statistically non-significant decrease in Alpha ratings to 95.65% (p=0.1560), while Vita Suprinity group maintained 100% Alpha scores after 12 months (Table 2, Figure 4 and Underlying data).

For marginal discoloration, e-max CAD group showed a non-significant decrease in Alpha ratings to 95.65 % (p = 0.1560) after 6 months and 87 % (p=0.6078) after 12 months (Table 3 and Figure 5).

Bravo ratings of 13% for discoloration and palpable marginal ditching were recorded in e-max CAD group after 12 month (Figure 6–Figure 8), while 4.35% Bravo rating were recorded in the Vita Suprinity group after 12 months.

### Table 2. Frequent distribution (%) of marginal adaptation for restorations of both groups at different evaluation time.

<table>
<thead>
<tr>
<th>Group</th>
<th>Base line</th>
<th>6 months</th>
<th>12 months</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alpha</td>
<td>Bravo</td>
<td>Alpha</td>
<td>Bravo</td>
</tr>
<tr>
<td>Vita Suprinity</td>
<td>23 (100%)</td>
<td>0 (0%)</td>
<td>23 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>IPS e.max</td>
<td>23 (100%)</td>
<td>0 (0%)</td>
<td>23 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>P value</td>
<td>1 ns</td>
<td>1 ns</td>
<td>0.1560 ns</td>
<td></td>
</tr>
</tbody>
</table>

ns; non-significant (p >0.05)
Table 3. Frequent distribution (%) of marginal discoloration for restorations of both groups at different evaluation time.

<table>
<thead>
<tr>
<th>Group</th>
<th>Base line</th>
<th>6 months</th>
<th>12 months</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alfa</td>
<td>Bravo</td>
<td>Alfa</td>
<td>Bravo</td>
</tr>
<tr>
<td></td>
<td>23 (100%)</td>
<td>0 (0%)</td>
<td>23 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Vita Suprinity</td>
<td>22 (95.65%)</td>
<td>1 (4.35%)</td>
<td>1 (4.35%)</td>
<td>0.3625 ns</td>
</tr>
<tr>
<td></td>
<td>20 (87%)</td>
<td>3 (13%)</td>
<td>20 (87%)</td>
<td>3 (13%)</td>
</tr>
<tr>
<td>IPS e.max</td>
<td>23 (100%)</td>
<td>0 (0%)</td>
<td>22 (95.65%)</td>
<td>1 (4.35%)</td>
</tr>
<tr>
<td></td>
<td>20 (87%)</td>
<td>3 (13%)</td>
<td>20 (87%)</td>
<td>3 (13%)</td>
</tr>
<tr>
<td>P value</td>
<td>1 ns</td>
<td>0.1560 ns</td>
<td>0.6078 ns</td>
<td></td>
</tr>
</tbody>
</table>

ns; non-significant (p >0.05)

Figure 4. Stacked column chart of marginal adaptation associated with restoration for both groups.

Figure 5. Stacked column chart of marginal discoloration associated with restoration for both groups.
structure, preserve enamel, and safeguard pulp vitality while achieving the desired aesthetic results\(^5,6\). Overtime, various ceramic materials have been developed for restoring posterior teeth\(^7-9\). The excellent combination of high mechanical strength and optical properties of lithium disilicate glass ceramic material made it the gold standard for comparison of new monolithic ceramic materials\(^9,11,12\). In our study CAD/CAM lithium disilicate ceramic material (IPS e.max CAD) was selected as the control to compare the clinical outcomes of the newly introduced zirconia-reinforced lithium silicate ceramic material (ZLS) (VITA Suprinity). Reinforced with about 10% zirconium dioxide, ZLS belongs to a new generation of CAD/CAM ceramic that combines positive mechanical characteristics of zirconia with glass-ceramic aesthetic appearance\(^22\). Still all findings regarding this new material are either laboratory or initial clinical experience findings\(^22-24\). Moreover, the indication for this material should be chosen with strict observation of the material-specific processing instructions regarding the necessary minimum wall thickness and required adhesive luting\(^22-23\). All of these findings make it crucial to conduct randomized clinical studies to verify the clinical performance of this new material.

In this study, a novel tooth preparation design; MDPT was selected. According to Venezian \(M^2\), this preparation design aims to minimize the loss of healthy tooth tissue and reduce the areas of dentin exposure. A hollow chamfer margin was created on the outer surface of the preparation to optimize the cutting of enamel prisms, thereby bonding and color blending at the transitional zone between tooth and restoration are enhanced\(^25-27\) (Figure 1), (Figure 2).

Regarding our results, Kaplan Meier analysis was used for survival assessment during the observational period of 12 months\(^32-35\); both Suprinity and e.max-CAD had a survival rate of 100%. All restorations remained in situ and in good function.

Comparison of our results to similar clinical studies regarding Suprinity is limited due to the novelty of the material\(^22-23\).

Clinical studies on e.max PCRs reported 98.99–100% survival rates over periods of 1–5 years\(^15,17-43\). In a long-term evaluation study, Guess \etal\(^\text{16}\) reported 100% survival rates for e.max PCRs with only evidences of relative failures as small repairable chipping after 8 years, but none of PCRs were fractured or de-bonded.

In our study, none of PCRs were de-bonded after 12 months. Other studies reported de-bonding of PCRs as one of the
common causes of failure\textsuperscript{13,14}. In those studies, debonding mainly was associated with endodontically treated teeth which were among the exclusion criteria in this study.

For marginal adaptation, all PCRs were rated Alpha at base-line and after 6 months. However; after 12 months, palpable margin ditching resulted in Bravo ratings for one of the e.max-CAD PCRs (4.35\%). Marginal deterioration might be attributed to degradation of cement due to fatigue in the oral cavity\textsuperscript{15,16}.

Suprinity PCRs sustained Alpha rating after 12 months, which can be attributed to the higher marginal quality and fatigue resistance of zirconia lithium silicate over lithium disilicate as reported by Preis et al.\textsuperscript{23,43}.

Nevertheless, results by Elsaka and Elnaghy\textsuperscript{24} were in disagreement with our results as they reported lower brittleness index of e.max CAD compared to Vita Suprinity, and consequently according to the parameters determined by Boccaccini\textsuperscript{44} and Chaysuwan et al.\textsuperscript{45}, e.max CAD might show lower marginal chipping rates than Suprinity\textsuperscript{24}.

Marginal discoloration of e.max PCRs has been reported by Guess et al.\textsuperscript{15,16} and Santos et al.\textsuperscript{37} as the most common clinical finding occurring in 37.5\% of PCRs after 7 years.

For marginal discoloration; three of e.max CAD (13\%) and one Vita Suprinity (4.35\%) restorations showed yellowish marginal staining (Bravo) after 12 months. Still both materials showed clinically acceptable margins.

The null hypothesis for this study was accepted as there was no statistically significant difference in clinical outcomes of the two tested ceramic materials.

**Strengths and limitations**

This study is randomized clinical trial conducted on relatively big sample size patients, in real clinical settings and was conducted efficiently. This is the first study to compare the clinical performance of e.max CAD and Vita Suprinity partial coverage restorations utilizing a novel preparation design (MDP). Our present study proposes a more conservative and efficient alternative to full coverage restorations for treatment of decayed, vital posterior teeth with high survival rates and excellent marginal quality.

The following limitations should be considered: The morphology driven preparation technique is a new design that wasn’t tested in previous randomized clinical trials before, reliability of the new design irrespective of the ceramic material used needs to be investigated in further clinical trials.

The short follow-up period was one of our study limitations, although no significant differences were found between the two materials, there was notable differences regarding marginal discoloration, thus longer term clinical trials are required to investigate the clinical performance of these ceramic materials.

**Conclusion**

Both Vita-Suprinity and e.max CAD partial coverage restorations are considered reliable treatment options for restoring larger defects in posterior dentition.

**Data availability**

**Underlying data**

Open Science Framework: Clinical Outcomes of Zirconia-reinforced Lithium Silicate Partial Coverage Crowns Compared to Lithium Disilicate Partial Coverage Crowns. A Randomized Controlled Split-mouth Clinical Study. https://doi.org/10.17605/OSF.IO/UNGCJ\textsuperscript{16}

This project contains the following underlying data:

- Results Data
  - KM curves.xlsx (Kaplein-Meier curves for crown survival)
  - Results raw.xlsx (Performance data for partial coverage crowns used)

**Extended data**

Open Science Framework: Clinical Outcomes of Zirconia-reinforced Lithium Silicate Partial Coverage Crowns Compared to Lithium Disilicate Partial Coverage Crowns. A Randomized Controlled Split-mouth Clinical Study. https://doi.org/10.17605/OSF.IO/UNGCJ\textsuperscript{16}

This project contains the following extended data:

- Study Settings
  - Grouping.xlsx (Patient grouping information)
  - ResearchRandomizer.csv (Randomizer results)

- Supplementary files
  - Trial protocol.docx (Trial protocol with copies of all forms used for data collection)

**Reporting guidelines**

Open Science Framework: CONSORT checklist and flow diagram for ‘Clinical outcomes of zirconia-reinforced lithium silicate partial coverage crowns compared to lithium disilicate partial coverage crowns. A randomized controlled split-mouth clinical study’ https://doi.org/10.17605/OSF.IO/UNGCJ\textsuperscript{16}

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

**Consent**

Written informed consent for publication of their clinical details was obtained from the patients.

**Grant information**

The author(s) declared that no grants were involved in supporting this work.


Open Peer Review

Current Peer Review Status: ❌ ✔

Version 1

Reviewer Report 03 August 2020

https://doi.org/10.5256/f1000research.19989.r66779

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✅ Samah Saker
Fixed Prosthodontics Department, Faculty of Dentistry, Mansoura University, Mansoura, Egypt

Thank you for inviting me to review this research article addressing a very important topic, clinical outcome of all ceramic partial coverage restorations, and the article is well-written. I agree with the authors that this study has a number of strengths (a randomized, split mouth study). However, I have some concerns about the design and the interpretation of the results that I believe should be addressed to make the paper stronger.

The title
It could be better to consider the following title for your study: Clinical outcome of CAD/CAM all-ceramic partial-coverage restorations: A Prospective clinical split-mouth study.

Abstract
Regarding the abstract section it's informative.

Introduction section
- Is short and the rationale of the study is not well presented, kindly add a short review about the previous clinical studies about all ceramic partial coverage restoration focusing in the preparation design, the cause of the use such design, and why in your study you use morphology driven preparation from biomechanical prospective.

Method section
- Regarding to tooth preparation, Kindly specify the following:
  - Cavity depth, cavity width (BL) in both premolar and molar.
  - The buccal and lingual extension of the interproximal box walls.
  - Regarding to the sentence, all undercuts were blocked......kindly, explain.
- Regarding to clinical outcome:
  - Each restoration was examined by one or two assessors? Kindly specify.
  - Although, 12 months of clinical service is too short period to assess the survival rate of the restoration as mentioned by the authors in the study limitation section, the finding could be considered as a preliminary finding.
Results section
○ Kindly, add a table of restoration distribution, for example, how many molars, premolars, and their frequency distribution.

○ Is there any patient drop out during the evaluation period or not, kindly add this part.

Discussion section
○ Your null hypothesis is accepted or rejected? And why? Kindly discuss.

○ The second paragraph in the discussion section, is fitted best to your introduction section, as it describe your study rationale.

References

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

*Competing Interests*: No competing interests were disclosed.

*Reviewer Expertise*: Prosthetic dentistry, Dental Biomaterial, Clinical Trials.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.
Oliver Schierz
Department of Prosthodontics and Materials Science, University of Leipzig, Leipzig, Germany

- The article contains 12 month results of a randomized clinical trial in partial crowns using two different dental ceramics.
- The title does match the content of the publication.
- The keywords are appropriate.
- The introduction is very short.
- The paper is linguistically sufficiently written and structured. Sample size calculation is insufficient, calculating for surface roughness, a parameter not reported and potentially secondary aim at best. This caused a severe miscalculation in number of patients needed to answer the scientific question, reflected by insignificant p-values in the results.
- According to material and methods each participant receives 2 crowns, one of ZLS and one LiS. When 14 participants are included this should result in 28 crowns, not 46. This difference should be explained and is probably due to more than one pair of partial crowns in each participant.
- The time frame of 12 months follow-up is much too short to find differences in respect that known clinical survival within 5 years is up 98 percent.
- A report about the distribution of included restorations in premolars and molars is missing.
- With the current number of participants the scientific value is low.

Is the work clearly and accurately presented and does it cite the current literature? Yes

Is the study design appropriate and is the work technically sound? Yes

Are sufficient details of methods and analysis provided to allow replication by others? No

If applicable, is the statistical analysis and its interpretation appropriate? No

Are all the source data underlying the results available to ensure full reproducibility?
Yes

**Are the conclusions drawn adequately supported by the results?**

No

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Prosthetic dentistry, clinical studies

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

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