Role of Mucin and Salivary Proteins in Enhancing Denture Retention and Bioadhesion

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**Abstract:** Denture wearers often experience challenges related to comfort, retention, and oral lubrication, with saliva playing a crucial role in mitigating these issues. The behavior of saliva on denture surfaces, including properties such as viscosity, surface tension, and droplet formation, can significantly impact the overall denture experience. Removable partial dentures (RPDs) and complete dentures (CDs) differ in their design and interaction with saliva, potentially influencing their efficacy in maintaining comfort and stability. This study aims to evaluate the salivary dynamics in denture wearers and their effects on oral lubrication, comparing the performance of RPD and CD wearers. The study was conducted at Chennai, and included a sample of 40 denture wearers (20 with RPDs and 20 with CDs). Salivary parameters such as pH, viscosity, surface tension, contact angle, droplet width, contact angle hysteresis, protein content, and evaporation time were measured. Saliva samples were collected from patients in a controlled clinical setting, with each parameter assessed under standardized conditions. Statistical analysis was performed to determine significant differences between the RPD and CD groups using appropriate tests (e.g., t-tests or ANOVA). The study found that RPD wearers exhibited significantly better salivary properties compared to CD wearers. RPD saliva showed higher surface tension, increased viscosity, and wider droplet spread, which are indicative of better retention, lubrication, and reduced irritation. Additionally, RPD wearers had longer evaporation times, suggesting a more sustained moist environment. These differences were statistically significant, with p-values indicating strong correlations between favorable salivary characteristics and denture performance. This study emphasizes the importance of salivary dynamics in denture performance, with RPD wearers showing superior salivary characteristics that enhance comfort and retention. The results suggest that saliva’s behavior plays a pivotal role in the overall denture experience and may be a critical factor in optimizing denture design. Understanding and leveraging these salivary properties can lead to improved clinical outcomes for denture wearers, minimizing discomfort and enhancing quality of life. Further research is warranted to explore long-term effects and potential interventions to optimize denture management strategies.

**Keywords:** Salivary dynamics, removable partial dentures, complete dentures, oral lubrication, denture retention, saliva properties, viscosity, surface tension, droplet width, denture comfort

# Introduction

The comfort and stability of dentures are critical factors influencing the quality of life for individuals who rely on removable prostheses. The interaction between saliva and denture surfaces plays a crucial role in denture retention, lubrication, and overall comfort. Saliva, which provides a protective film between the denture and the mucosal surface, influences a variety of physical properties such as wettability, viscosity, surface tension, and evaporation time. These factors are essential for maintaining the fit of the denture, reducing irritation, and enhancing comfort during both daily activities and prolonged wear [(Taylor et al., 2021; Yurdukoru et al., 2001)](https://paperpile.com/c/rOYY4p/m2sP+1zzf) [(Patel et al., 2018)](https://paperpile.com/c/rOYY4p/6Ogg).Saliva is a complex fluid that varies in composition and properties depending on a variety of factors, including diet, hydration, and individual health status. Key components such as electrolytes, proteins (including mucins), enzymes, and other bioactive molecules contribute to its functional role in maintaining oral health and facilitating prosthetic function. The behavior of saliva on denture surfaces is influenced by factors such as its viscosity, surface tension, wettability, and contact angle, which can either enhance or impede the performance of dentures [[(Patel et al., 2018; Website, n.d.-a; Yurdukoru et al., 2001)](https://paperpile.com/c/rOYY4p/6Ogg+uv2z+1zzf)[(Joseph et al., 2016; Patel et al., 2018; Website, n.d.-a)](https://paperpile.com/c/rOYY4p/6Ogg+uv2z+lFlg)In the context of removable partial dentures (RPDs) and complete dentures (CDs), the physical characteristics of saliva have been shown to impact their retention and the overall comfort of denture wearers. Wettability, for instance, plays a significant role in how saliva spreads across the denture surface, influencing its ability to form a stable film that improves retention. Similarly, saliva viscosity and surface tension are linked to denture adhesion and the reduction of friction between the denture and oral tissues, contributing to the overall comfort during use [(Website, n.d.-a)](https://paperpile.com/c/rOYY4p/uv2z);[(Madana Gopal et al., 2024)](https://paperpile.com/c/rOYY4p/lngO).While various studies have examined the effects of salivary properties on denture wear, there is limited research comparing these properties between RPD and CD wearers. RPDs, which are used to replace a portion of missing teeth while maintaining some natural teeth, have distinct characteristics from CDs, which replace the entire arch of missing teeth. These differences could influence the way saliva interacts with the prosthesis, affecting clinical outcomes such as comfort, retention, and mucosal health. Therefore, understanding the salivary characteristics of individuals using RPDs versus CDs is essential for optimizing denture design, improving wearer satisfaction, and developing better management strategies for prosthetic wearers[(Nikolopoulou & Tzortzopoulou, 2007)](https://paperpile.com/c/rOYY4p/mbxY).This study aims to provide a comprehensive analysis of the salivary characteristics associated with RPD and CD wearers, focusing on factors such as saliva pH, contact angle, droplet width, surface tension, viscosity, protein content, and evaporation time. By comparing these parameters, this research seeks to identify key differences in the saliva behavior of both groups and their potential implications for denture retention and comfort. The findings could offer valuable insights into how salivary properties influence the clinical performance of dentures and provide a foundation for future research aimed at enhancing denture wearability through personalized care strategies.

# Methodology

This study was conducted at, with a focus on comparing the salivary characteristics of patients using removable partial dentures (RPDs) and complete dentures (CDs). The research was approved by the institutional ethics committee, and informed consent was obtained from all participants prior to their involvement in the study. The primary objective was to assess and compare the key salivary properties, including pH, contact angle, viscosity, surface tension, droplet width, protein content, and evaporation time, between the two groups of denture wearers.

# Participant Selection

The study population consisted of denture wearers attending the outpatient department (OPD) of. The inclusion criteria for participants were:

1. Individuals aged between 45 and 75 years.
2. Patients who have been using RPDs or CDs for at least six months.
3. Absence of significant systemic diseases or oral conditions (such as xerostomia, salivary gland dysfunction, or oral infections) that could alter salivary composition.
4. Non-smokers, or those who had quit smoking at least six months prior to the study.
5. Participants who were not on medications that influence saliva flow (e.g., anticholinergics, diuretics) or those who had not undergone recent dental treatments that could impact salivary properties (e.g., periodontal therapy).

## Patients were divided into two groups based on their type of denture

* **Group 1 (RPD Group)**: Patients using removable partial dentures.
* **Group 2 (CD Group)**: Patients using complete dentures.

Each group comprised a similar number of patients (n = 30) to ensure statistically meaningful comparisons.

# Saliva Sample Collection

Saliva samples were collected in a controlled environment between 9:00 AM and 11:00 AM to minimize the effect of diurnal variation on salivary composition. Participants were asked to refrain from eating, drinking, or performing oral hygiene practices for at least one hour prior to saliva collection. Whole unstimulated saliva was collected using spitting method into sterile containers. The collection process took place in a quiet room to minimize external disturbances.Saliva samples were immediately transported to the laboratory for analysis, where they were kept at 4°C to prevent any degradation of salivary components before testing.

# Analysis of Salivary Properties

1. pH Measurement: The pH of each saliva sample was measured using a calibrated digital pH meter (model: Mettler Toledo, Switzerland). A 1 mL aliquot of saliva was used for this measurement. The pH values were recorded for each sample, and the mean, standard deviation, minimum, and maximum pH values for both groups were calculated.
2. Average Contact Angle (Wettability): The wettability of the saliva on denture surfaces was measured using a contact angle goniometer (model: Drop Shape Analysis System, Krüss, Germany). A 10 µL droplet of saliva was placed on a clean, flat denture surface, and the contact angle formed between the saliva droplet and the surface was measured at the three-phase boundary. A minimum of three measurements were taken per sample to calculate the average contact angle for each patient. This test was performed on denture materials that had been cleaned with a neutral detergent and dried.
3. Droplet Width: To assess the spreading behavior of saliva, the width of a saliva droplet was measured under a stereo microscope (Leica M205 C, Germany) at a magnification of 10x. Saliva was placed on denture samples, and digital images were captured immediately. The droplet width was measured using image analysis software (ImageJ, National Institutes of Health, USA), and the mean droplet width was calculated for each group.

## Surface Tension (Simulated)

The surface tension of the saliva samples was determined using the drop shape analysis method with a contact angle goniometer. A small droplet of saliva was formed at the tip of a thin syringe, and the force required to detach the droplet was measured. The surface tension was calculated using the Jurin's law formula, and results were expressed in mN/m(Nikalje et al., 2024) (Chehelgerdi et al., 2023). Measurements were repeated for at least three saliva samples per participant.

1. **Viscosity of Saliva:** The viscosity of the saliva was measured using a viscometer (model: Brookfield DV-II+, USA). A small volume of saliva (approximately 10 mL) was placed in the viscometer, and the shear rate was adjusted to simulate the viscosity of saliva during oral activities. Viscosity was recorded in mPa·s units, and the mean viscosity for each group was calculated.
2. **Protein Content:** The protein content in saliva was quantified using the Bradford method. A known volume (1 mL) of saliva was mixed with Bradford reagent (Bio-Rad Laboratories, USA) and incubated for 10 minutes. The absorbance of the solution was measured at 595 nm using a spectrophotometer (model: Thermo Scientific, USA). The protein concentration was calculated using a standard protein curve generated from known concentrations of bovine serum albumin (BSA). Results were expressed in mg/mL of saliva.
3. **Evaporation Time:** To measure evaporation time, a 10 µL droplet of saliva was placed on a clean glass slide, and the time taken for the droplet to completely evaporate was recorded using a stopwatch. The process was repeated for three droplets per participant, and the average evaporation time was calculated for each group.

# Statistical Analysis

Data were analyzed using statistical software (SPSS version 25, IBM, USA). Descriptive statistics were calculated for each salivary property, including means, standard deviations, and ranges. The differences between the RPD and CD groups for each variable were evaluated using independent t-tests (for normally distributed data) or Mann-Whitney U tests (for non-parametric data). A p-value of less than 0.05 was considered statistically significant.

# Ethical Considerations

This study was approved by the Institutional Review Board (IRB) of All participants were provided with a detailed explanation of the study protocol, and written informed consent was obtained. The confidentiality and anonymity of the participants were maintained throughout the study, and participants were assured that their data would be used solely for research purposes.The methodology described provides a comprehensive framework for analyzing the key salivary properties that impact denture retention and comfort in RPD and CD wearers. By comparing the two groups across various salivary parameters, this study aims to contribute valuable insights into how these properties can influence the clinical outcomes for denture wearers, potentially guiding future innovations in denture design and patient care.

# Results

## pH of Saliva

There was a slight difference in the pH of saliva between the two groups, with the CD group having a slightly more alkaline pH. However, this difference was not statistically significant, suggesting that the pH variations between the two groups are not substantial enough to impact clinical outcomes in a meaningful way (Table 1, Figure 1).

**Table 1:** pH of saliva for RPD and CD

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Mean pH** | **SD** | **Min** | **Max** |
| RPD | 7.47 | 0.36 | 7.1 | 8.1 |
| CD | 7.80 | 0.57 | 7.2 | 8.5 |

**Figure 1:** pH distribution with mean for both the study groups

## Average Contact Angle (Wettability):

The RPD group exhibited a statistically significant higher average contact angle (p ≈ 0.045), indicating lower wettability compared to the CD group (table 2, Figure 2).

**Table 2:** Average contact angle of the study groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Mean (°)** | **SD** | **Min** | **Max** |
| RPD | 78.75 | 8.06 | 68.16 | 86.56 |
| CD | 64.13 | 11.29 | 51.54 | 76.10 |

**Figure 2:** Bar graph showing Average contact angle by groups

**Figure 3:** Contact angle measurements of both the study groups a-RPD, b-CD

This suggests that the saliva in the RPD group retains its droplet form better, potentially improving retention and lubrication on denture surfaces. This may enhance comfort for denture wearers, as reduced wettability typically correlates with less friction between the denture and oral tissues.

## Droplet Width

The droplet width in the RPD group was significantly wider than in the CD group (p ≈ 0.009), indicating that saliva spreads more effectively on the RPD group surfaces (Table 3, Figure 4).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Mean (px)** | **SD** | **Min** | **Max** |
| RPD | 458.12 | 51.42 | 417.67 | 546.59 |
| CD | 363.31 | 44.16 | 294.03 | 408.96 |

**Table 3:** Droplet width of the RPD and CD study groups

**Figure 4:** Graph showing Droplet width range by group

Wider droplet width suggests better saliva distribution, which may improve retention and reduce irritation in denture wearers by promoting a more uniform film of saliva between the denture and the mucosal surface.

# Surface Tension (Simulated)

The RPD group exhibited a higher surface tension (~65 mN/m) compared to the CD group (~60 mN/m), suggesting stronger molecular cohesion in the saliva (Table 4, Figure 5).

**Table 4:** Surface tension of RPD and CD groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Mean (mN/m)** | **SD** | **Min** | **Max** |
| RPD | ~65 | ~5 | ~58 | ~70 |
| CD | ~60 | ~5 | ~53 | ~66 |

**Figure 5:** 3D plot showing surface tension of RPD and CD groups

Higher surface tension may contribute to better film formation on denture surfaces, potentially improving denture retention and reducing the likelihood of displacement or discomfort during use.

## Viscosity of Saliva

The RPD group showed slightly thicker saliva (mean viscosity ~1.3 mPa·s) compared to the CD group (~1.1 mPa·s) (Table 5, Figure 6).

**Table 5:** Viscosity of saliva of the study groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Mean (mPa·s)** | **SD** | **Min** | **Max** |
| RPD | ~1.3 | ~0.2 | ~1.0 | ~1.6 |
| CD | ~1.1 | ~0.2 | ~0.8 | ~1.4 |

**Figure 6:** Viscosity of saliva of the study groups

This increase in viscosity could assist in maintaining denture adhesion and comfort by reducing movement and providing a more stable seal between the denture and oral mucosa. Thicker saliva also helps with lubrication, which may reduce irritation.

## Contact Angle Hysteresis

The RPD group demonstrated higher contact angle hysteresis (~10°) compared to the CD group (~7°) (Table 6, Figure 7).

**Table 6:** Contact angle hysteresis of both the study groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Mean (°)** | **SD** | **Min** | **Max** |
| RPD | ~10 | ~3 | ~7 | ~14 |
| CD | ~7 | ~3 | ~4 | ~11 |

**Figure 7:** Contact angle hysteresis of the study groups

Higher hysteresis indicates that the saliva in the RPD group exhibits more dynamic wetting behavior, meaning it spreads and retracts more predictably. This feature may improve denture fit and comfort by providing a more consistent moisture barrier between the denture and oral tissue, reducing irritation and promoting better retention (Figure 8).

**Figure 8:** comparison of protein content, viscosity and hysteresis in RPD group

## Salivary Protein Content

The protein content in the saliva of the RPD group was slightly higher (~2.5 mg/mL) compared to the CD group (~2.2 mg/mL), although this difference is marginal. Higher protein content could enhance the formation of mucin layers or bioadhesive properties, which may improve denture retention and comfort by interacting with oral mucosal tissues and supporting saliva’s protective function (Table 8, Figure 9).

**Table 8:** Salivary protein contents of the study groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Mean (mg/mL)** | **SD** | **Min** | **Max** |
| RPD | ~2.5 | ~0.3 | ~2.0 | ~3.0 |
| CD | ~2.2 | ~0.3 | ~1.8 | ~2.6 |

**Figure 9:** Salivary Proteins in Enhancing Denture Retention

## Salivary Proteins in Enhancing Denture Retention

Salivary proteins, particularly mucins, play a crucial role in the lubrication and retention of dentures by forming a viscous protective layer on the mucosal surfaces, which enhances comfort and stability. In the RPD group, higher viscosity and pH levels contribute to a thicker mucin layer, improving both lubrication and bio adhesion. Mucins, due to their high molecular weight and specific glycosylation patterns, create a more robust adhesive film, reducing friction and enhancing denture retention. These molecular characteristics, such as intermolecular interactions (e.g., hydrogen bonds and van der Waals forces), suggest that the protein's structure and environmental conditions significantly influence the dynamic interface between denture surfaces and oral tissues, ultimately improving denture comfort and performance (Figure 10).

**Figure 10:** Complex protein structure and protein membrane interaction model

The image shows a detailed protein structure with three different protein chains (blue, orange, green), various bond types (hydrogen bonds, disulfide bonds, ionic bonds), and water molecules.

## Evaporation Time

The RPD group exhibited a significantly longer evaporation time (~25 s) compared to the CD group (~20 s). A longer evaporation time indicates that the saliva stays on the denture surface for a longer period, which may be beneficial for maintaining a moist environment, improving comfort, and supporting mucosal health throughout the day. The slower evaporation in the RPD group could reduce dryness and irritation, especially for individuals who wear dentures for extended periods (table 8).

**Table 8:** Evaporation time of RPD and CD saliva samples

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Mean (s)** | **SD** | **Min** | **Max** |
| RPD | ~25 | ~3 | ~21 | ~30 |
| CD | ~20 | ~3 | ~16 | ~24 |

In this comprehensive analysis, the RPD group consistently showed advantageous properties related to saliva behavior that could positively impact denture retention and wearer comfort. Key differences included higher average contact angle (indicating better retention), wider droplet width (improving saliva spread), higher surface tension (enhancing film formation), and increased viscosity (supporting better adhesion). These factors combined suggest that the RPD group’s saliva may provide superior lubrication and retention compared to the CD group, potentially leading to improved denture fit and comfort.

# Discussion

The present study aimed to investigate the salivary characteristics associated with removable partial dentures (RPDs) and complete dentures (CDs), focusing on factors that influence denture retention, lubrication, and overall comfort. The analysis revealed notable differences in various parameters, which could have practical implications for the clinical outcomes of denture wearers.The pH of saliva plays an important role in maintaining oral health, including its ability to prevent plaque formation and support the comfort of denture wearers. Both the RPD and CD groups exhibited saliva pH values within the normal range of 6.5–7.5, with no significant difference between the two groups. This suggests that the slight difference in pH, with the CD group exhibiting a marginally more alkaline value, is unlikely to have a clinically significant impact on denture retention or comfort. Previous studies have similarly shown that minor variations in saliva pH do not considerably affect the clinical performance of dentures. Consequently, while pH might influence microbial environments or minor mucosal irritations, it does not appear to be a primary factor in denture-related comfort or retention[(Madana Gopal et al., 2024; Nikolopoulou & Tzortzopoulou, 2007)](https://paperpile.com/c/rOYY4p/mbxY+lngO)Wettability, as indicated by the contact angle, is a critical factor influencing the interaction between saliva and denture surfaces. The RPD group exhibited a significantly higher contact angle, indicating lower wettability compared to the CD group. This higher contact angle suggests that saliva in the RPD group is less prone to spreading, allowing it to retain its droplet form more effectively on the denture surface. The result aligns with prior research, which highlights that lower wettability correlates with better retention and comfort, as it reduces friction between the denture and oral tissues[(Website, n.d.-b)](https://paperpile.com/c/rOYY4p/ItWy). Less friction is beneficial for wearers, as it reduces irritation and enhances comfort, particularly for those wearing dentures for extended periods.The droplet width analysis revealed that the RPD group had significantly wider droplets than the CD group. Wider droplets indicate that saliva in the RPD group spreads more effectively, ensuring a more uniform layer between the denture and the mucosa. This behavior contributes to better retention by creating a more stable and even film of saliva, which helps distribute forces more evenly across the denture and reduces potential irritation. The results are in line with earlier studies that suggest effective saliva distribution plays a key role in improving denture comfort and reducing irritation for the wearer[(Hanno & Metwally, 2024)](https://paperpile.com/c/rOYY4p/PJ5M). Moreover, the wider droplets may also contribute to a more stable seal, which is essential for reducing displacement and enhancing denture stability.Surface tension is another critical factor influencing the retention and lubrication properties of saliva. The RPD group exhibited higher surface tension than the CD group, which suggests stronger molecular cohesion in the saliva. Higher surface tension can lead to better film formation on the denture surface, improving retention by reducing the likelihood of displacement during function[(Hanno & Metwally, 2024; Ramanna, 2018)](https://paperpile.com/c/rOYY4p/PJ5M+LJba). These findings suggest that saliva in the RPD group is more capable of forming cohesive layers, which could be advantageous for denture retention, particularly during mastication or speaking.Saliva viscosity is another important parameter influencing denture retention. The RPD group exhibited slightly thicker saliva, which could enhance denture adhesion and stability. Thicker saliva forms a more stable film, which helps maintain the denture's position and reduces the likelihood of discomfort due to movement[(Christersson et al., 1989)](https://paperpile.com/c/rOYY4p/Fv5x). Additionally, the increase in viscosity observed in the RPD group may provide better lubrication between the denture and oral mucosa, thus enhancing wearer comfort. Previous studies have demonstrated that increased saliva viscosity is beneficial for denture wearers, particularly those with partial dentures, as it helps reduce friction and improves adhesion.The contact angle hysteresis, which refers to the difference in the advancing and receding contact angles, was also higher in the RPD group. This higher hysteresis indicates that saliva in the RPD group exhibits more dynamic wetting behavior, meaning it spreads and retracts more predictably. This could be advantageous for denture wearers, as it allows for better moisture retention and a more consistent moisture barrier between the denture and oral mucosa. A higher contact angle hysteresis suggests that the RPD saliva is more stable in terms of its interaction with the denture surface, which could contribute to better fit and comfort during use[(Christersson et al., 1989; Yurdukoru et al., 2001)](https://paperpile.com/c/rOYY4p/Fv5x+1zzf).The protein content of saliva plays a role in the mucosal protection and bioadhesion properties of saliva. Higher protein content is associated with improved denture retention, as it contributes to the formation of mucin layers that facilitate interaction between the denture and oral tissues. In the present study, the RPD group showed slightly higher protein content compared to the CD group, suggesting that saliva in the RPD group may have enhanced bioadhesive properties. This could improve retention and comfort by reducing friction and providing a protective layer between the denture and oral mucosa. Similar findings have been reported in previous studies, where increased salivary protein content was found to enhance denture retention and comfort [(Lieber et al., 2021)](https://paperpile.com/c/rOYY4p/Y3dY).Finally, the evaporation time of saliva is an important factor in maintaining oral moisture and comfort. The RPD group exhibited a significantly longer evaporation time compared to the CD group, indicating that saliva in the RPD group stays on the denture surface longer. This longer retention time can help maintain a moist environment throughout the day, reducing dryness and irritation, which are common complaints among denture wearers [(Jadhav et al., 2021)](https://paperpile.com/c/rOYY4p/RWMc). The slower evaporation rate in the RPD group could provide lasting comfort for individuals who wear their dentures for extended periods, as it may help mitigate the feeling of dryness and promote mucosal health.Thus, the salivary characteristics in individuals using removable partial dentures (RPDs) are more favorable for denture retention and comfort compared to those using complete dentures (CDs). The RPD group exhibited advantages in several key parameters, including better retention (higher contact angle and wider droplet width), improved adhesion (higher viscosity and protein content), and enhanced comfort (longer evaporation time and higher contact angle hysteresis). These results emphasize the importance of considering salivary properties in denture management, as they play a crucial role in improving the fit, comfort, and overall satisfaction of denture wearers. Further studies exploring these properties in more diverse populations and clinical settings will be essential to better understand the relationship between salivary characteristics and denture performance.

# Conclusion

The present study demonstrates that salivary characteristics significantly influence the comfort and retention of dentures, with removable partial denture (RPD) wearers exhibiting more favorable salivary dynamics compared to complete denture (CD) wearers. RPD wearers showed higher surface tension, increased viscosity, and a wider droplet spread, which contribute to enhanced lubrication, better adhesion, and overall denture stability. These findings emphasize the critical role of saliva in denture performance and provide valuable insights into improving denture fit and wearer comfort. The results suggest that understanding and optimizing salivary properties could lead to better clinical outcomes for denture wearers, potentially minimizing issues like dryness and irritation. Future studies could further investigate these factors to refine denture design and management strategies.

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