

# Factors that Influence the Clinical Longevity of Ceramic Unit Restoration: A Scoping Review

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## ABSTRACT

**Statement of Problem:** Ceramic restorations can be essential in dental rehabilitation aesthetic and functional, but its longevity and treatment plan need to be good settled down. Different material options, manufacturing techniques and protocols are available. It is important to map the literature to know the state of the art about of clinical failures related to these fixed prostheses.

**Purpose:** Evaluate the rate of survival of single restorations (crowns and ceramic veneers) as well as identify the types of clinical complications reported.

**Material and methods:** A scoping review was conducted from the MEDLINE/Pubmed, Embase, Scopus, Web of Science and Cochrane Library. A search of all published literature until June 2021 was based on the following keywords: ('dental crown' OR 'ceramic veneer' OR 'porcelain veneer' OR 'dental veneer' OR 'dental porcelain') AND ('survival rate' OR 'ceramic restoration failure' OR 'prosthesis complication' OR complication).

**Results:** The most reported biological complications were need for treatment endodontic and detachment. The complications and technical failures involved, mainly, fractures and cracks in ceramics. There were also cases of pigmentation marginal.

**Conclusion:** The survival rate of single ceramic restorations is high. The main factors influencing restoration failures are bruxism, operator inexperience and inadequate cementation.

**Keywords:** Bruxism, ceramic, failure.

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## I. INTRODUCTION

Improvements in adhesive systems and the development of new generations of ceramics have supported the growing demand for more aesthetic treatments, from crowns metal-free to ultra-thin laminates and ceramic fragments [1]. Among the main ceramic materials developed to combine strength and aesthetics in pure ceramic crowns, there is zirconia. Single crowns and partial denture fixed to the base of this material have gained popularity due to its excellent mechanical properties. biocompatibility and aesthetics [2]. To fully meet the aesthetic demand, requires an outer layer of feldspathic porcelain. However, the chipping of the ceramic layer is the most common complication of this type of restoration [3].

Lithium disilicate ceramics, on the other hand, promise esthetic and minimally invasive, covering all types of single restorations. Can be adhesively bonded to the tooth structure through surface treatments (acidhydrofluoric) and chemical interactions (silane), allowing excellent mechanical properties and aesthetic. Monolithic application reduces the

susceptibility to chipping, which is known in restorations with zirconia and feldspathic porcelain [4].

However, clinical longevity depends on a number of factors, such as marginal adaptation, proper occlusal adjustment, ease of cleaning and maintenance of the oral hygiene [5]. Reference [6] evaluated the clinical results of 6855 restorations, including crowns, laminates, and fixed bridges, manufactured in disilicate of lithium. 83% of failed restorations happened in the first year after cementation and 50.6% happened in the first 3 months. Ceramic chipping (41.5%) and fracture (37.3%) were the two main reasons, in addition to fiberglass post fracture.

Complications do not always reflect substandard care or clinical failures. Most of the time, these are conditions that occur during or after oral rehabilitation. performed properly. Thus, knowledge about the clinical complications that can occur in the fixed prosthesis increases the clinician's ability to diagnose correctly, develop the most appropriate treatment plan, communicate expectations realistic to patients and plan the time intervals needed for maintenance [7].

Although a large number of articles present data on

complications clinics [1] - [15] none provide a combination of the findings of these studies and establish general conclusions about the performance of single ceramic restorations. Therefore, the objective of this review was to evaluate the survival rate of single restorations. (ceramic crowns and laminates), as well as identifying the types of clinical complications reported.

## II. MATERIAL AND METHODS

In order to examine the extent and nature of existing research around the failures in single ceramic fixed prostheses, this scope review was conducted from in accordance with the recommendations of the PRISMA-ScR declaration (PRISMA extension for scoping reviews). The question which is intended answer is: "What factors can influence failures in fixed prostheses unitary ceramics?".

### A. Eligibility Criteria

For inclusion in this review, the inclusion and exclusion criteria were considered listed in Table I.

TABLE I: INCLUSION AND EXCLUSION CRITERIA

Criteria	Description
Inclusion	- Clinical studies including randomized clinical trials, studies prospective and retrospective cohort - Systematic reviews and meta-analysis
	- Studies reporting the clinical performance of crowns and tooth-supported ceramic laminates
	- Studies that described the concepts of failure and success
Exclusion	- Studies in vitro, case reports and articles not available in data base
	- Studies based only on medical records and interviews, without clinical evaluation
	- Studies reporting the clinical performance of direct composites
	- Studies reporting the clinical performance of rehabilitation supported by implants
	- Studies dealing only with fixed partial dentures and indirect restorations

### B. Information Source and Search Strategy

Several databases were searched, MEDLINE/Pubmed, Embase, Scopus, Web of Science and Cochrane Library, to identify studies carried out that evaluated the clinical performance of single ceramic restorations. The search was carried out in June of 2021, and was limited to human studies and only in the English language. The search was extended to gray literature using Google Scholar and the database OpenGrey. The search strategies defined for the databases described above are listed in Table II. The keywords were consulted in the Medical Subject Headings (MeSH) and subjects.

### C. Selection of Studies

The electronic search was conducted by two independent researchers in several moments. The first stage involved removing the duplicates. After this phase, the most relevant studies were selected by reading the title and abstract in an appropriate way independent and the differences were resolved through discussion between the researchers. The final step was to obtain the full texts for evaluation according to with the eligibility criteria, in addition to the manual search for article references selected.

### D. Data extraction

Qualitative data extracted from the studies were: first author, year of publication, type of study, location, type of restoration, type of material, manufacturing method, number of operators and observation time. As for the data quantitative, the following were extracted: number of patients, age of participants, number of restorations, location of restorations (anterior, premolar or molar), number of complications, type of complications and survival rate.

In this review, failure was defined as crowns that suffered some type of complication such as core fracture, porcelain fracture, loss of retention, among others, and needed to be replaced or resulted in the loss of the pillar element. While the complication was considered for restorations that remained in function, however had some type of mechanical (detachment, crack) or biological intercurrent (endodontic treatment), but did not result in the need for another part or replacement of the dental element.

## III. RESULTS

### A. Selection of Studies

The electronic and manual search resulted in 291 studies. After deleting the duplicates and from the reading of the title and abstract, 28 studies were sent for evaluation of the complete text. Of these, 14 studies were excluded and the remaining 14 were included and used for data extraction. The selection process is described in Fig. 1.

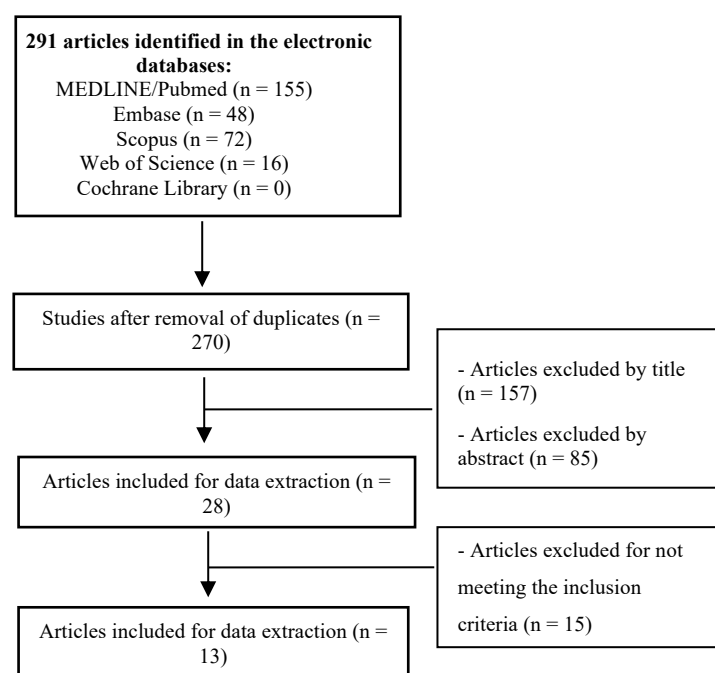


Fig. 1. Flowchart of the study selection process.

### B. Results from Individual Sources of Evidence

The included studies were published between 2003 and 2021. studies are presented in Table III. Quantitative data related to clinical performance of unit rehabilitations are shown in Table IV.

TABLE II: SEARCH STRATEGY

Pubmed	Embase	Scopus	Web of science	Cochrane
failure[Title/Abstract]) OR ("dental veneer"[Title/Abstract] AND "prosthesis failure"[Title/Abstract]) OR ("dental veneer"[Title/Abstract] AND "prosthesis failure"[Title/Abstract]) OR ((dental porcelain[Title/Abstract] AND (prosthesis failure[Title/Abstract])) OR ((ceramic veneer[Title/Abstract] AND (prosthesis failure[Title/Abstract]))) OR ((porcelain veneer[Title/Abstract] AND (prosthesis failure[Title/Abstract]))) OR ((crown[Title/Abstract] AND (ceramic restoration failure[Title/Abstract]))) OR ((dental porcelain[Title/Abstract] AND (ceramic restoration failure[Title/Abstract]))) OR ((ceramic veneer[Title/Abstract] AND (ceramic restoration failure[Title/Abstract]))) OR ((porcelain veneer[Title/Abstract] AND (ceramic restoration failure[Title/Abstract]))) OR ((crown[Title/Abstract] AND (survival rate[Title/Abstract]))) OR ((dental porcelain[Title/Abstract] AND (survival rate[Title/Abstract]))) OR ((ceramic veneer[Title/Abstract] AND (survival rate[Title/Abstract]))) OR ((porcelain veneer[Title/Abstract] AND (survival rate[Title/Abstract]))) OR ((crown[Title/Abstract] AND (complications[Title/Abstract]))) OR ((dental porcelain[Title/Abstract] AND (complications[Title/Abstract]))) OR ((ceramic veneer[Title/Abstract] AND (complications[Title/Abstract]))) OR ((porcelain veneer[Title/Abstract] AND (complications[Title/Abstract]))) AND (complications[Title/Abstract])) NOT (implant[Title/Abstract]) AND (ffrit[Filter])	('dental crown':ti,ab,kw OR 'ceramic veneer':ti,ab,kw OR 'porcelain veneer':ti,ab,kw OR 'dental veneer':ti,ab,kw OR 'ceramic restoration failure':ti,ab,kw OR 'prosthesis complication':ti,ab,kw OR 'porcelain complication':ti,ab,kw)	( TITLE-ABS-KEY ( "dental crown" OR "dental veneer" OR "dental porcelain" OR "ceramic veneer" OR "porcelain veneer" ) AND TITLE-ABS-KEY ( "prosthesis failure" OR "ceramic restoration failure" OR "survival rate" OR "complications" ) AND NOT TITLE-ABS-KEY ( implant ) )	TS=("dental crown" OR "ceramic veneer" OR "porcelain veneer" OR "dental veneer" OR "indirect veneer" OR "dental porcelain") AND TS=("survival rate" OR "ceramic restoration failure" OR "prosthesis failure" OR "prosthesis failure" OR complications ) NOT TS=(IMPLANT)	"dental crown" OR "ceramic veneer" OR "porcelain veneer" OR "dental veneer" OR "dental porcelain" in Title Abstract Keyword AND "survival rate" OR "ceramic restoration failure" OR "prosthesis failure" OR "complications" in Title Abstract Keyword NOT implant in Title Abstract Keyword

TABLE III: CHARACTERISTICS OF THE INCLUDED STUDIES

Study	Study Design	Restoration	Type of material	Fabrication mode	N° of operators	Observation period (months)
[3]	Cohort Prospective	Monolithic crown	Zirconia	CAD/CAM	1	60
[2]	Cohort Prospective	Monolithic crown	Zirconia	CAD/CAM	1	12
[20]	Cohort Retrospective	Monolithic crown	Zirconia	CAD/CAM	1	60
[21]	Cohort Prospective	Monolithic crown	Zirconia	CAD/CAM	5	41
[10]	Cohort Retrospective	Laminate and crown	Feldspatic	Conventional	1	600
[15]	Cohort Retrospective	Laminate	Leucite	Conventional	1	84
[12]	Cohort Prospective	Laminate	Feldspatic	Conventional	1	132
[14]	Cohort Retrospective	Laminate	Lithium dissilicate Leucite	Conventional	2	240
[13]	Cohort Retrospective	Laminate	Feldspatic	Conventional	3	60
[11]	Systematic Review	Crown	Lithium dissilicate	CAD/CAM	NR	24 - 120
[4]	Cohort Prospective	Crown	Lithium dissilicate	Conventional	NR	30
[1]	Cohort Prospective	Laminate	Lithium dissilicate	Conventional	Students	6 - 24
[5]	Cohort Retrospective	Crown	Lithium dissilicate	Conventional	Students	35

TABLE IV: QUANTITATIVE DATA EXTRACTED FROM THE INCLUDED STUDIES

Study	No. of patients	Age range [years]	N° of restorations	Location of the restorations	Complications	Failure	Survival Rate [%]
[3]	50	NR	50	Posterior	D = 2	FR = 1	98
[2]	65	49,52	65	Posterior	DM = 1	0	100
[20]	162	56	205	Anterior = 48 Posterior = 168	L = 2 D = 9 E = 9 O = 9	F = 3 FA = 1 R = 6 EX = 7 C = 1 O = 1 F = 2	88
[21]	13	53,1	40	Anterior = 2 Posterior = 38	0	L = 1 FA = 1	90
[10]	10	49,11	44	Anterior	0	0	100
[15]	31	46,16	101	Anterior	D = 8 E = 2 L = 1 C = 2	F = 7 EX = 1	95
[12]	104	42,1	384	Anterior	D = 3 L = 3	F = 15 EX = 1	95

TABLE IV: QUANTITATIVE DATA EXTRACTED FROM THE INCLUDED STUDIES (CONT)

Study	No. of patients	Age range [years]	N° of restorations	Location of the restorations	Complications	Failure	Survival Rate [%]
[14]	84	44,42	318	Anterior = 3 Posterior = 315	T = 2 L = 1 D = 1 C = 1	F = 13 T = 6 L = 2 D = 2 C = 1	92,5
[13]	15	26,1	78	Anterior = 72 Posterior = 6	DM = 2 L = 1 T = 2	F = 2	97,4
[11]	154	NR	204	Anterior = 15 Posterior = 189	E = 2 D = 1 C = 2	E = 3 C = 1 F = 3 R = 2 F = 3	95,5
[4]	45	45	327	Anterior = 176 Posterior = 151	R = 3 L = 5	FR = 1 E = 1 C = 2	97,9
[1]	29	26	205	NR	D = 3 DE = 3 DM = 80	AC = 6	97,1
[5]	47	41	88	Anterior = 79 Posterior = 9	DM = 16 T = 3	F = 3	96,6

NR – Not reported; D – Detachment; FR – Root fracture; DM – Marginal pigmentation; L – Chipping; E – Endodontics; C – Caries; F – Ceramic fracture; FA – Fracture due to adhesive failure; R – Retention loss; EX – Extrusion; FA – Fracture of the antagonist tooth; T – Ceramic crack; AC – Color change; DE – Incisal wear; O – Others (gingivitis, sensibility, etc.)

### C. Failures and complications in crowns

In the included studies, a total of 1,001 crowns were installed in 546 patients and evaluated for a period of 1 to 50 years. All studies reported the number of participants, who received crowns of different materials, zirconia [6], [7], [9], [11], ceramics feldspathic [2]-[4], [8], lithium disilicate [1], [2], [5], [12], [14] and leucite [2], [10], and the location (previous or later).

The reviewed studies of zirconia crowns showed that they were made by CAD technique (computer-aided design) and CAM (computer-aided manufacturing) of crowns monolithic. Using the pooled data, it was found that there was a total of 23 failures and 33 complications. The most common failure was the loss of the pillar element (n = 7) due to endo/perio injury, followed by loss of retention (n = 6) and coronary fracture (n = 5). How much to complications, there were 6 different types, with the highest occurrence of detachment (n = 11), accompanied by the need for endodontic treatment (n = 9) and presence of secondary caries (n = 9).

The survival rate reported by [2] was 100%, since no absolute failures were reported during a 1-year follow-up period. Only one restoration was recorded as marginal discoloration, but they were made the necessary adjustments and there was no need for replacement. High rate of survival was also found by [3] at the end of 5 years of follow-up. Only 2 mechanical complications (detachment) were recorded. resolved by recommendation, and a root fracture in an upper premolar left endodontically treated.

Considering the same 5-year follow-up period, [20] found a lower survival rate, 88%. The main flaws were extraction of the pillar element and loss of retention, while complications involved detachment, secondary caries and need for endodontic treatment. All the extracted teeth had previous endodontic treatment. Reference [21] reported rate survival rate (90%) for the follow-up of 40 monolithic

crowns.

Reference [10] published a follow-up study of up to 50 years of crowns of feldspathic porcelain (n = 44) in anterior teeth with a survival rate of 100%. The research was carried out in a private environment, in patients with excellent oral hygiene practices and who regularly attended the dentist.

Likewise, descriptive studies on disilicate crowns of lithium showed high survival rates. Reference [11] conducted a review systematic to evaluate the clinical results of the confection from the technology CAD/CAM 204 crowns were installed in 154 patients and the survival rate reported was 95.5%. The main failures were the need for endodontic treatment (n = 3) and ceramic fracture (n = 3).

Other authors reported high survival rates for fabrication by the technique conventional. Reference [4] conducted a prospective study to identify complications in 327 lithium disilicate pressed crowns for up to five years. The main failure and complication found was ceramic fracture and chipping, respectively, representing a survival rate of 97.9%. Reference [5] showed a similar result, with a survival rate of 96.6%, with emphasis on marginal discoloration as the most frequent complication.

### D. Failures and Complications in Laminates

The laminates made of feldspathic porcelain had a high rate of survival. In the study by [10], all laminates survived the period of follow-up for up to 50 years. Reference [12] conducted a prospective study in the high 384 veneers were installed in 104 patients in the upper anterior teeth. Preparations with incisal overlap were performed using the mock up technique. Immediate dentin sealing was applied when more than 50% of the dentin was exposed during preparation. Overall, chipping was the main complication (n = 15), while the absolute failure was the ceramic fracture (n = 15), representing survival rate of 95%.

Reference [13] recently published a retrospective study with the follow-up of 78 laminates installed in 15 patients



according to the protocol “CH no-prep”, with an observation interval between 36 and 60 months. the survival rate was 97.4% and the most frequent absolute failure reported was ceramic fracture. The authors concluded that after proper patient selection, unprepared laminates represent an effective and conservative option.

Reference [1] conducted a prospective study in which 205 laminates of Lithium disilicate were installed in 29 patients by undergraduate and graduate students. University graduate. All restorations were cemented with Variolink Veneer (Ivoclar Vivadent) or RelyX Veneer (3M ESPE, St. Paul, MN, USA). the period of follow-up ranged from 6 months to 2 years and were reported as absolute failure to color change (n = 6). It is noteworthy that marginal pigmentation was observed in 58.6% of patients, regardless of the time of installation and especially in those with poor oral hygiene and biofilm buildup. No patient had fractures, but they were observed incisal wear and detachment, related to bruxism and habits parafunctional.

Reference [14] also observed the clinical performance of laminates manufactured in lithium disilicate, in addition to those composed of feldspathic and leucite ceramics for up to 20 years. Half of the patients were diagnosed with bruxism (n = 42). were registered 24 failures and 5 complications. The most frequent reason for failure was the fracture of the ceramic (n = 13), followed by the triple (n = 6). The survival rate was 92.5% and the analysis statistic revealed a significantly higher failure rate for restorations in patients with bruxism. Likewise, the most common failure of manufactured laminates in leucite, in the study by [15], it was the ceramic fracture (n = 7), with a fee of 95% survival.

#### IV. DISCUSSION

The mapping of clinical complications in single ceramic rehabilitations provided an overview of scientific evidence, reflection on the factors that influence on failures and a wide range of research themes that can lead to a better understanding of the determinants of the longevity of restorations. Were included prospective, retrospective cohort studies and a systematic review.

None of the included studies compared the conventional manufacturing method to the CAD/CAM technology. This technology allows the fabrication of esthetic and accurate even with high-strength materials like lithium disilicate and zirconia [2]. Reference [11] found a survival rate of 95.5% in crowns made of lithium disilicate, while Reference [2] found rate 100% survival rate on crowns fabricated from zirconia. This explains that regardless of the material, the digital flow in daily practice is reliable.

Very varied follow-up periods were recorded, from 6 months to 50 years. The retrospective study by [10] was conducted in a private environment (private practice) by an experienced operator. Clinical data and radiographs, at least once a year, of patients rehabilitated with crowns and laminates from 1966 to 2016. One of the factors that can justify the absence of flaws is the convenience sample, including patients who attended regularly and performed excellent oral hygiene practices. In addition, the professional's experience can influence work longevity. This suggests the importance of continuous monitoring,

maintenance and oral hygiene.

On the other hand, studies in which the operators were undergraduate and graduate students showed a higher rate of complications, especially esthetic ones. Reference [1] investigated the longevity of ceramic laminates, relating failures to the patient, material and operator. Marginal pigmentation was observed in most pieces cemented, especially in patients with poor oral hygiene and stone accumulation. A similar result was found by [5] in search with operators inexperienced and high rate of marginal discoloration. The reason for these complications it may be the inappropriate application of techniques and the correct selection of the type of cement.

There were no reports from studies on the association between the incidence of complications and the location of the restorations, with the exception of [5], who justified the high survival rate due to the fact that most crowns are located in the anterior region (89.7%). Likewise, none of the studies stated whether the age group had an impact about survival.

Among the biological complications, the need for treatment stands out endodontic. This fact may be associated with excessive reduction in tooth structure natural, especially in young patients, in addition to continuous pulp trauma. Reference [20] reported endodontic problems in 4% of crowns. Similar findings were found in the studies by [11] and [15], with an event rate of 2% of endodontic complications. The incidence of secondary caries was low, reported by some studies [1], [2], [10] and it can be linked to poor oral hygiene or the presence of adaptation marginal inappropriate. Reference [4] found a secondary caries in the palate of the upper left canine. This patient received 28 crowns in one session and the dentist reported an error when cementing the work, resulting in the gap penetrable marginal.

Regarding technical complications, the main observations were detachment and chipping or cracking of the ceramic. Reference [15] found rate of 8% detachment, being the most frequent complication of the study. a possible. The reason for the increase in the rate is the design of the preparation of the restorations included in this study. Reference [11] stated that the registered detachment occurred due to lack of adequate retention, as the abutment tooth had less than 3 mm. Taxes of Minor detachments were found by [11] and [14]. Although the crowns monoliths have less propensity to chipping, small cracks were observed in areas of high load and lesser dental support (marginal crests) in 3 of the 151 posterior restorations (2%) from the study by [4].

In this study, the main reason for replacements of crowns and laminates ceramics was the fracture of ceramics. This finding is in accordance with the findings of systematic reviews that identified material fractures as the main failure of restorations [16]-[19]. Reference [15] found, of the 8 total failures, 7 fractures in laminates based on leucite, which led to a fracture rate of 7% after 7 years. a possible the justification would be adhesion to dentin, which would increase the risk of flexion, considering that dentin is more flexible than enamel. The authors suggested the use of ceramics with better mechanical properties, such as lithium disilicate and zirconia. In addition, a better bonding protocol, with the aid of immediate sealing dentin (IDS),

when adhesion occurs to a large dentin substrate, it could increase fracture resistance.

In this sense, [12] evaluated the performance of ceramic laminates with immediate dentinal sealing, with an 11-year follow-up. The data show that the IDS was beneficial for the survival of the laminates, since the teeth that do not received (n = 32) had significantly more failures (n = 4) than teeth with IDS (n = 60; failures, n = 0). Most fractures reported in this study were associated with bruxism. Eighteen patients were diagnosed and received an occlusal splint stabilizer. They were instructed about the higher risk of fracture if they did not use it. Nine failures were recorded in patients who did not use it correctly.

Following the same relationship with bruxism, [14] observed a risk 8 times higher for failure in patients with this activity. Excessive occlusal force can increase microleakage and the formation of gaps in the cervical margin, harming the retention of the restoration, which can lead to cracks and fractures. Patients received a occlusal splint and were instructed on the importance of adherence to use, but not all joined. Reference [21] evaluated that despite the excellent strength of the material, the crowns monoliths in zirconia fractured due to thin occlusal thickness and bruxism.

## V. CONCLUSION

Based on the findings and within the limitations of this scope review, conclude that the survival rate of single ceramic restorations is high (88 to 100%), regardless of the material and type of restoration. The most biological complications reported were need for endodontic treatment and detachment. already the complications and technical failures mainly involved fractures and cracks of the ceramics, often associated with bruxism. The aesthetic complications, in particular marginal pigmentation were common when the operator was inexperienced.

## CONFLICT OF INTEREST

We do not have any conflict of interest.

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