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Longevity of cantilever resin-bonded bridges: a scoping review

Przeżywalność adhezyjnych mostów jednobrzeżnych: przegląd piśmiennictwa

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Summary

Introduction. *The cantilever resin-bonded bridge represents today a real alternative to the implant-supported prosthesis. Over time, these bridges have evolved significantly following the understanding of the bonding principles and the biomechanics of these prostheses. Their use, however, remains limited for some practitioners because of their concern over their reliability. Through this study, we tried to evaluate its longevity as well as the various factors that could influence it.*

Materials and methods. *Performed on the PubMed and EBSCOhost databases using MeSH words and the Boolean operators "AND" and "OR" to reach the search equation. After selecting the articles, the data were extracted and analysed.*

Results. *Twenty-four various studies (retrospective and randomized clinical trials) were accepted.*

Conclusion. *The cantilever resin bonded bridge can be considered as a minimally invasive, successful and long-lasting therapy in the management of single tooth edentulous cases. Its survival rate has been estimated at 88.3 % to 100 % over relatively long evaluation periods.*

Streszczenie

Wstęp*. Adhezyjne mosty jednobrzeżne stanowią dziś alternatywę dla protezy wspartej na implancie. Z biegiem czasu mosty te znacznie ewoluowały wraz z lepszym zrozumieniem zasad wiązania i biomechaniki tych protez. Jednakże nie są często stosowane z powodu obaw niektórych lekarzy co do ich trwałości. W tym badaniu staraliśmy się ocenić ich długoczasowość, a także różne czynniki, które mogą na nią wpływać.*

Materiały i metody. *Wykorzystano bazy danych PubMed i EBSCOhost przy użyciu słów MeSH i operatorów boolowskich „AND" i „OR" do przeprowadzenia wyszukiwania. Po wybraniu artykułów dane zostały wyodrębnione i przeanalizowane.*

Wyniki. *Przyjęto 24 różne badania (retrospektywne i randomizowane badania kliniczne).*

Wniosek. *Adhezyjne mosty jednobrzeżne można uznać za minimalnie inwazyjną, skuteczną i długotrwałą terapię w przypadku braku pojedynczego zęba. Wskaźnik przeżywalności oszacowano na 88,3% do 100% w stosunkowo długich okresach oceny.*

Introduction

The bonded bridge notion was introduced in 1963 by Rochette as a non-invasive fixed prosthesis.[1] The teeth bordering the edentulous gap were not pre-prepared clinically. In 1977, Howe and Denehy used the Rochette design to replace a missing anterior tooth. However, with this design the failure rate was high due to premature debonding. The mechanism of retention has been improved, and in 1982, Livaditis and Thompson proposed the Maryland bridge with a retentive mechanism etching the inner face of cast retainers made from non-noble porcelain-fused to-metal alloys.[2]

These bridges have evolved significantly following the understanding of the bonding principles and the biomechanics of these prostheses. This evolution has particularly interested both the materials type and the design. Indeed, the classical bonded bridge is composed of a pontic and two wings that are bonded on the lingual faces of the two teeth bordering the edentulous gap. However, several clinical cases exhibited partial debonding of a winglet due to the difference of mobility of the abutments, and oftentimes, the solution was to eliminate the debonded winglet and to continue using the bridge with only one wing.[2,3] This solution showed satisfactory results, which contributed to the emergence of a new design of bonded bridges: the bonded bridge with a single winglet or a cantilever bonded bridge (CBB).[4,5] It may be indicated for patient with good hygiene, low caries index and only one tooth missing. The abutment tooth should be free of caries or restorations, except for small cavitated lesions that will be included in the preparation. Other inclusion criteria are large coronary volume, low Le Huche index, absence of tooth mobility and recession and favourable occlusion: Class II division 1, open bite, Class III (inverted bite) and the incisor butt.

This bridge is contraindicated when having unfavourable occlusion ratios: Class I with significant overbite and Class II division ?.[2] Also, some practitioners hesitate to recommend this type of bridge because of the fear over its reliability as a definitive prosthetic solution. Generally, it has been used as a temporary prosthesis before placing the implant-supported fixed restoration.[6] Thus, we decided to carry out this study to argue the longevity of the CBB and examine the different factors influencing it.

Materials and methods

Research question

The research question is: What is the survival rate of CBBs? It is in the form of PICO;

P: Patients who have an edentulous space limited to one missing tooth; I: Intervention by CBB; C: conventional bridges; O: The longevity of CBB

Search strategy

An electronic search on PubMed and EBSCOhost from January 2000 to January 2021 was conducted using the boolean operators “AND”, “OR” and “NOT” combined with our keywords and the Medical Subject Headings (MeSH) section to search for all relevant articles in English and French. The search was being renewed from the first day of the search until the completion of the review by activating a request to update the results by e-mail.

Inclusion criteria

All of the following criteria had to be satisfied:

– study type (prospective or retrospective cohort study, and randomized controlled clinical trial) to include the maximum number of clinical situations,
– in-vivo study in the case of patients clinically examined with follow-up visits,
– the indicated therapy is the tooth-supported CBB,

– studies with at least three years of follow-up.

Exclusion criteria

The exclusion of articles selected after reading the titles and abstracts was made according to predefined criteria which are as follows:

– the year of publication before 2000,
– the language is other than English or French,
– the therapeutic choice is not the CBB,
– in-vitro studies,
– the study does not mention longevity for the therapeutic choice.

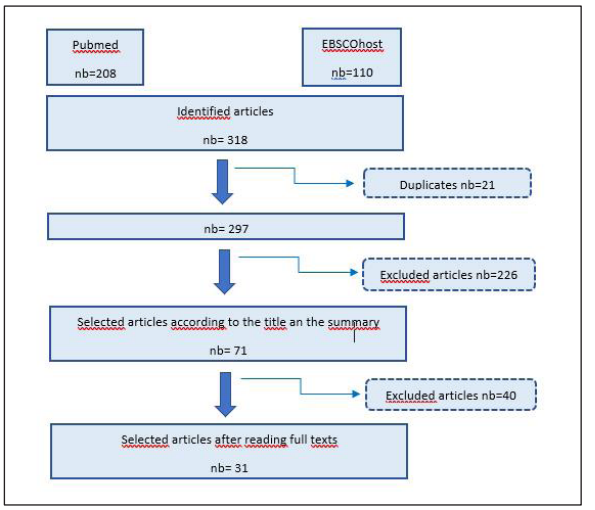

Fig. 1. Outline of the bibliographic search.

Selection process

Articles selection was made in three steps:

– at first, the results obtained from the two consulted databases were downloaded as "PDF" and subsequently the software "Mendeley" was used to eliminate duplicates,
– then, the choice was based on the title of the article and its summary to guide the study towards the answer to the research question,
– finally, all the sorted articles were read in full. We also used the abstracts for articles whose full texts were not found. We estimate that reading only the summary of these articles is sufficient to obtain a conclusion,
– data extraction.

Data on the following variables were collected and organized in tables: Study type, Author's name, Publication's year, Study's purpose, Intervention's equipment and method, Result and Conclusion.

Results

The bibliographic search on Pubmed and EBSCOhost identified 318 articles that were then sorted according to a well-defined selection process. FEventually, twenty-four selected articles (retrospective, prospective and randomized clinical trial) were obtained (Figure 1).

Statistical analysis was conducted to extract the data and answer the research question.

Survival was defined as the maintenance of CBBs *in situ* with or without modification during the observation period. Success was defined as the CBBs retention without any detachment, fracture or chipping. Failure included any type of complication that led to the removal or replacement of the restoration. Complication was defined as any modification observed on both the CBB and the abutment between the day of bonding and the last day of the study that led or not to the failure of the corresponding restoration. Thus, the success rate and the failure rate were calculated by dividing, respectively, the number of successful restorations and the number of failed restorations by the total number of CBBs. Clinical data and different rates extracted from the included studies are summarized in Table1.

Our review concerned 956 patients (405 women and 300 men). The mean age is 38.6 ± 11.41 years ranging from 10 to 83 years.

T a b l e 1. Results of studies iIncluded in this pape

Author/ year/ Reference	Patients:		Number of bridges	Prostheses materials	Bonding materials	Clinical follow-up (months)	Complications		Survival rate (%)	Success rate(%)	Failure rate(%)
	Number	Mean age					Number	Type			
Botelho [5] (2000)	31	NS	33	NS	NS	NS	1	Debonding	NS	97	NS
Botelho [7] (2002)	69	NS	82	NS	NS	36	4	Debonding	95.1	95.1	NS
Chai [8] (2005)	NS	NS	47	Metal-ceramic	NS	60	8	Debonding	93.6	81	6.4
							1	Decay			
Kern M [9] (2005)	16	NS	21	Ceramic (IN-ceram)	Panavia or Panavia 21	60	1	Fracture	95.2	95.2	4.8
Botelho [10] (2006)	214	50.2	269	Metal-ceramic	Panavia EX or Panavia 21	51.7	12	Debonding	97	95.5	3
							2	Extraction			
Thomason [11] (2007)	26	67	54	Metal-ceramic	NS	60	32	Debonding	79.6	27.8	20.4
							4	Fracture			
							3	Extract-ion			
Garnett [3] (2006)	NS	17.6	62	Metal-ceramic	Panavia	59.3	25	Debonding	47	47	53
Kern [12] (2011)	16	NS	22	In-Ceram alu-mina In-Ceram Zirconia	Panavia 21 TC	111	1	Fracture	95.5	95.5	4.5
Sasse [13] (2012)	25	33.3	30	Zirconia (IPS e.maxZirCAD)	Panavia 21 Multilink– Automix	41.7	2	Debonding	100	93.3	0

Table 1. cont.

Author/ year/ Reference	Patients:		Number of bridges	Prostheses materials	Bonding materials	Clinical follow-up (months)	Complications		Survival rate (%)	Success rate(%)	Failure rate(%)
	Number	Mean age					Number	Type			
Lam [14] (2012)	39	NS	39	Metal-ceramic	NS	115.2	15	Debonding	82.1	53.8	28.2
							2	Chipping			
Sailer [15] (2013)	28	35.5	35	Vitro-ceramic (Empress, e.maxPress)	Tetric Ceram, Panavia F HFO and Variolink	72	2	Chipping	100	94.3	0
Sasse M [16] (2014)	37	32.7	42	Zirconia	Panavia 21 TC	61.8	2	Debonding	100	92.9	0
							1	Decay			
Sun Q [17] (2014)	35	42	35	Vitro-ceramic	Variolink (Ivoclar Vivadent)	46.57	0	NS	100	100	0
Saker S [18] (2014)	40	36.1	40	Metal-ceramic Alumina ceramic	Panavia 21	34	3	Debonding	95	87.5	5
							2	Fracture			
Sailer [19] (2014)	15	27.5	15	Zirconia	Panavia 21 TC	48	2	Debonding	100	86.7	0
Botelho [20] (2014)	153	55.4	211	Metal-ceramic	Panavia EX Panavia 21	113.2	28	Debonding	90	84.4	10
							5	Extraction			
Klink [6] (2016)	18	33	23	Zirconia	Multilink Variolink	36	1	Debonding	100	87.5	0
							2	Chipping			

T a b l e 1. cont.

Author/ year/ Reference	Patients:		Number of bridges	Prostheses materials	Bonding materials	Clinical follow-up (months)	Complications		Survival rate (%)	Success rate(%)	Failure rate(%)
	Number	Mean age					Number	Type			
Kern M [21] (2016)	16	33.3	22	In ceram zirconia In ceram alumina	Panavia 21 TC	188.7	2	Fracture	-95.4% at 10 years -81.8% at 18 years	90.9	9.1
Botelho [22] (2016)	15	50.5	13	Metal-ceramic	Panavia Kuraray	216.5	0	NS	100	100	0
King [23] (2015)	NS	46	476	Metal-ceramic	Panavia 21 TC	60 et 120	67	Debonding Fracture	86.3	85.9	13.7
Kern M [24] (2017)	87	32	108	Zirconia	Multilink Automix panavia 21	92.2	6	Debonding	98.2	90.7	0.8
							1	Loss			
Shahdad S [25] (2018)	26	NS	58	Zirconia (Y-TZP)	Multi-Link Automix	36.2	9	Debonding	82.8	82.8	7.2
							1	Fracture			
Saker S [26] (2020)	40	36.1	40	Metal-ceramic Alumina ceramic	Panavia 21, Kuraray	106.7	7	Debonding	92.5	75	7.5
							3	Fracture			
Naenni [27] (2020)	10	32.4	10	Zirconia (IPSe. maxZirCAD)	Panavia 21 TC, Kuraray	120	2	Debonding	100	80	0

NS: not specified.

T a b l e 2. Tooth preparation depending on the type of the restoration material

Material	Studies	Tooth preparation	Secondary retention means	Survival rate
Metal-ceramic	Saker S (2014) and Saker S (2020)	Supragingival finishing line, minimally invasive preparation on the lingual surface 1 mm below the incisal edge	A shallow mesial groove (2 mm long, 1 mm wide, 0.5 mm deep)	100% at 5 years 100% at 10 years
	Botelho (2016)	Abutment surfaces were prepared conservatively	Proximal grooves.	100% at 18 years
Vitro-ceramic	Sailer (2013)	No preparation for anterior teeth. Minimal preparation for inlay on posterior teeth	No secondary retention means	100% at 5 years
	Sun Q (2014)	Enamel preparation. Reduction of the lingual surface from 0.5 to 0.8 mm and the proximal surface from 0.5 to 1 mm. Supragingival chamfer of 0.5 mm. Angles rounding	No secondary retention means	100% at 5 years
Alumina ceramic	Kern (2011) Kern M (2016)	Enamel preparation. A 0.5 mm reduction in the lingual surface	A shallow groove on the cingulum. A small proximal box (2 mm long, 1mm wide, 0.5 mm deep)	94.4% at 10 years 95.4% at 10 years and 84.8% at 18 years
	Saker S (2014) Saker S (2020)	Supra gingival finishing line. Minimally invasive preparation on the lingual face at 1mm below the incisive edge	A shallow mesial groove (2mm long, 1 mm wide, 0.5 mm of deep)	90% at 5 years 85% at 10 years
Zirconia	Kern (2011) Kern M (2016)	Enamel preparation. A 0.5 mm reduction in the lingual surface	A groove on the cingulum. A small proximal box (2 mm long, 1mm wide, 0.5 mm deep)	94.4% at 10 years 100% at 10 years
	Sasse M (2014)	Enamel preparation	A slot and a proximal box.	100% at 10 years
	Sailer (2014)	Minimally invasive preparation	Two vertical proximal grooves (6 degree conicity). A cingulum pinhole	100% at 4 years
	Kern M (2017)	Enamel preparation. A thin cervical chamfer and incisive shoulder. Proximal finishing line does not extend beyond the contact area. The sharp edges have been carefully smoothed	A proximal box (2mm long, 2 mm wide, 0.5 mm deep). A cingulum pinhole	98.2% at 10 years
	Naenni (2020)	Enamel preparation	Two proximal vertical grooves. A cingulum pinhole	100% at 10 years

The survival rate is clearly a valid issue for subjects between 20 and 40 years compared to those younger than 20 years.

Some studies[10,11,13,15,18] have specified that the CBB has only been indicated for patients free from periodontal diseases.

In the selected studies, iaedentulism concerned a single tooth and was located in the maxillary and/or mandibular arch with a predominance of maxillary iaedentulism. Each patient had one or more missing teeth. The total number of 1790 CBBs were identified: 650 maxillary bridges and 337 mandibular bridges. For the remaining 803 bridges, their location has not been specified. In all, 843 anterior CBBs and 302 posterior CBBs were indicated to restore both aesthetics and function. The survival rates of these bridges varied from study to study.

Patients with traumatic occlusion or parafunction such as bruxism and habituals disorders (pencil biting), were excluded from certain studies. Only two studies[17,19] specified that their patients presented a dental open bite (an overjet> 0.5 mm and an overbite <1 to 1.5). In the former study, the survival rate at four years was 100% and for the latter study, it was 100% at ten years. In our study, the abutment was chosen according to clinical and radiological parameters: the absence of cavities and the presence of a sufficient coronary height.

For the abutment preparation, some studies were interested in clinical cases conducted in different university hospitals. The teeth preparation was made either by students supervised by a senior staff member or by a senior staff members directly. Two studies specified the number of bridges made by students and those made by seniors with their respective number of complications. It was also found that the abutment preparation was slightly different depending on the type of the restoration material (Table 2).

The authors of the selected studies were

Table 3. Survival rate, success rate and failure rate depending on the restoration material and the follow-up period of CBBs

Materials	Follow-up period (years)	Survival rate (%)	Success rate (%)	Failure rate (%)
Metal-ceramic	3	95.1	95.1	NS
	5	77.7	72.4	15.4
	10	78	74.8	14.9
	18	100	100	0
Vitro-ceramic	5	100	94.3	0
Alumina ceramic	5	93.6	91.4	4.9
	10	91.6	87.1	7
	18	81.8	NS	NS
Zirconia	3	94.2	87.9	8.6
	4	100	86.7	0
	10	97.5	88.7	1.8

NS : Not specified.

Table 4. Retention rate, success rate and failure rate depending on the bonding material and the follow-up period of CBBs

Bonding material	Number of CBBs	Follow-up period (years)	Retention rate (%)	Success rate (%)	Failure rate (%)
Panavia 21 or panavia EX	1407	3	93.6	93.3	0
		4	86.7	86.7	0
		5	90.3	85.9	12.6
		6	95.2	92.9	0
		10	90.8	85.3	6.2
		18	100	95.5	4.6
Multilink-Automix	122	3	91.1	87.9	2.9
		10	85.8	90.7	4.2
Variolink	37	3	100	87.5	0
		5	100	100	0

interested in assessing the clinical performance of both metal-ceramic and all ceramic CBBs (Table 3).

Different bonding materials were used in the studies to retain the CBB as long as possible in the mouth. In fact, a retention rate is defined by the percentage of CBBs that have not undergone detachment throughout the study period. (Table 4)

Discussion

The answer to our research question consists in the assessment of the CBB survival rate and the determination of the factors influencing it. Indeed, in the 31 included articles, we were able to put together groups for different survival rates. Each study had a different follow-up period (3, 4, 5, 6, 10 and 18 years) with corresponding survival rate permitting to assess the short or long term CBBs survival . *Chai*[8] demonstrated in 2005 in his comparative study of bonded bridges and conventional bridges, a better prognosis in favour of CBB with a success rate of 81% at five years. Also, *Lam*[14] in his 2012 study on the longevity of implants and CBBs did not find a significant difference in the survival rate between the two solutions. It was often assumed that the survival rate is higher in females than in males. Hypothetically, this could be linked to oral hygiene measures performed more regularly by women than by men. There are conflicting results concerning the influence of patient's age on the longevity of fixed restorations. CBBs are mostly indicated as the first-line treatment option for a single missing tooth in adolescents, but in our study, it was found that the CBBs survival rate in patients younger than 20 years is the lowest (47%), which can be explained by the lack of motivation, insufficient oral hygiene, presence of oral habits, etc. commonly present in adolescence.[3] For patients between 20 and 60 years, the survival rate is higher than 90%, which confirms the importance of maturity in improving the CBB prognosis. [13,15, 16, 17,21,24] For patients older than 60 years, this rate is reduced to 70%.[11] This can only be due to oral

changes observed in the elderly, including teeth loss, occlusion ratios modification, etc.

The periodontal conditions of the abutment teeth should be assessed (bone level, mobility, attached gingiva) and the use of bonded bridges during active periodontal disease should be avoided. The absence of gingival inflammation, the presence of a harmonious marginal gingiva and the respect for the biological space are necessary factors for the prosthesis longevity.[10,11,13,15,18]

It was also found that practitioners choose the CBB for the maxillary arch more than the mandibular one. However, the comparison between the corresponding success rates showed an insignificant difference in favour of maxillary CBB. Moreover, it was found that the replacement of anterior missing teeth with a CBB is more frequent than the replacement of posterior missing teeth (73.6% vs 26.4%). This can be explained by the fear of fracture due to occlusal constraints. Statistical analysis showed that the posterior CBBs survival rate is higher (95%) than that of the anterior CBBs (92%) but this difference was not statistically significant. Further studies should be performed in this context.

The indication for bonded bridges is limited to cases where the supporting teeth are almost free from decays, in ortho-position, with a satisfactory coronary height, a favourable crown/root ratio and a low Le Huche index. The presence of a tooth with a short clinical crown of which the enamel area usable for bonding is limited, may restrict the bonded bridge indication. In our review, some practitioners mentioned the need for a sufficient coronal height, including *Sun*[17] who required a coronal height of at least 4 mm. Supporting teeth in malposition require an accentuation of the preparations in order to parallel them, which results in a largely dentine bonding surface leading to more frequent detachments. Also, a ceramic restoration placed in a non-harmonized occlusal context may be fractured due to occlusal interference. Similarly, bruxism or any other parafunction can inevitably lead to the CBB fracture.

A CBB has a better chance of surviving when it is less subjected to occlusal stress like in cases of open bite and limited overlap. *Naenni*[17] found a survival rate of CBB of 100% at 10 years of study for cases with an open bite manifested by an overjet >0.5 mm and an overbite <1 to 1.5 mm.

Long-term success of CBBs and any type of prostheses depends on several factors:

- a prosthetic decision adapted to the clinical situation,
- the completion of pre-prosthetic treatments,
- the adequate preparation respecting the aesthetic, biological and functional imperatives,
- an impression encompassing all the details of the preparation,
- strictly respected bonding protocol.

Indeed, it has been found that the practitioner's clinical experience is involved in the success of these bridges. This was confirmed by comparing the prostheses made by students and those made by senior staff members whose success rate of restorations was slightly higher.

The guidelines for CBB abutment preparation are similar to those of other bonded bridges.[2] However, the design of the preparation depends on the intended prosthetic material. For anterior metal-ceramic CBBs, the limit of the preparation on the lingual face must be 1 mm below the incisal edge avoiding the greyish appearance that might appear by transparency at this level. For technical reasons, all-ceramic CBBs require a more invasive preparation with rounded angles to avoid the risk of the framework fracture. Additionally, no secondary retention devices are recommended for vitro-ceramic (Empress, E.max Press) CBBs while for zirconia CBBs, secondary retaining devices

are necessary to overcome their debonding problems (68.6%).[24,26]

Metal-ceramic CBBs are still indicated by dentists who seek to benefit from the mechanical properties of metal alloys.[3,8,10,11,20,22,23] Through our review, we found significant CBB survival rates with 100% for cobalt-chromium and 89% for nickel-chromium alloys.

The 5-year survival rates of 100% for vitro-ceramic CBBs and 93.6% for alumina ceramic CBBs show that these bridges are more durable than metal-ceramic CBBs. It has even been found that at 10 years, zirconia CBBs are more successful in surviving compared to metal-ceramic CBBs (97.5% vs 78%).

Bonding is an unavoidable daily dental restorative act involving a double interface between three components: the base, which is the enamel for our restoration, the bonding polymer, the restorative material, which can be metallic or ceramic.

To optimize the bonding performance, it is necessary to consider the type of the interfaces since the nature of the bonding polymer and the surface treatment will depend on it. Three bonding materials were mainly used in the studied papers. Panavia was used to bond most of the CBBs (1407) and showed significant short- and long-term retention rates (93.6% at 3 years and 90.8% at 10 years). The Variolink and the Multilink, also showed satisfactory retention rates, but the former seems to perform the best with a limited number of detachments. *Sasse*,[13] in his study, did not find any significant difference between Panavia and Multilink, for which respective survival rates were 93.1% and 92.9%. These almost similar retention, survival and success rates between bonding polymers without adhesive potential (Multilink-Automix and Variolink) and those with adhesive potential (Panavia) reflect the importance of surface treatment in the bond between enamel, bonding polymer and restoration.

The success of dental CBBs also depends considerably on the dental technician's experience. In reviewed studies, different materials were used for the fabrication of CBBs. Their implementation was either by the conventional technique or by the CAD/CAM technique. By comparing the corresponding survival rates, we find that the latter has no significant influence on the longevity of CBBs. Each technique has its advantages and disadvantages and it is rather their properly conducted implementation that can lead to the prosthesis success.

Conclusion

To encourage the choice of CBBs, we sought to determine their survival rate. It was found that the CBB can be considered as a minimally invasive, effective and lasting solution for the management of both anterior and posterior maxillary and mandibular edentulism. Its survival rate has been estimated at 88.3% to 100% during relatively long evaluation periods.

The analysis of the initial situation, the selection of patients, the realization of stabilizing and retentive micro-preparations as well as the strictness in the bonding protocol by the choice of an adhesive in accordance with the prosthesis framework material and the associated surface treatment, are the key points for the CBBs success.

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