CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

Survival rates and clinical procedures of Resin-bonded bridges in the anterior region : An integrative review.

Anne Le Guen Bentata

Dissertação conducente ao Grau de Mestre em
Medicina Dentária (Ciclo Integrado)

Gandra, 28 de maio de 2020

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

Anne Le Guen Bentata

Dissertação conducente ao Grau de Mestre em
Medicina Dentária (Ciclo Integrado)

Survival rates and clinical procedures of Resin-bonded bridges in the anterior region : An integrative review.

Trabalho realizado sob a Orientação
do Professor Doutor José Manuel Mendes

Declaração de Integridade

Eu, acima identificado, declaro ter atuado com absoluta integridade na elaboração deste trabalho, confirmo que em todo o trabalho conducente à sua elaboração não recorri a qualquer forma de falsificação de resultados ou à prática de plágio (ato pelo qual um indivíduo, mesmo por omissão, assume a autoria do trabalho intelectual pertencente a outrem, na sua totalidade ou em partes dele). Mais declaro que todas as frases que retirei de trabalhos anteriores pertencentes a outros autores foram referenciadas ou redigidas com novas palavras, tendo neste caso colocado a citação da fonte bibliográfica.

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

Declaração

Eu, José Manuel da Silva Mendes, com a categoria profissional de Professor Auxiliar do Instituto Universitário de Ciências da Saúde, tendo assumido o papel de Orientador da dissertação intitulada "*Survival rates and clinical procedures of resin-bonded bridges in the anterior region: an integrative review*", do Aluno do Mestrado Integrado em Medicina Dentária, Anne Le Guen Bentata, declaro que sou de parecer favorável para que a dissertação possa ser depositada para análise do Arguente do Júri nomeado para o efeito para Admissão a provas públicas conducentes à obtenção do Grau de Mestre.

Gandra, 28 de Maio de 2020

O Orientador

Acknowledgments

I would like to thank my supervisor Professor José Manuel Mendes. Thank you for your availability and valuable comments on this dissertation.

I would like to thank the entire CESPU staff, who accompanied me during these five years and who allowed my professional reconversion and personal fulfilment.

Thank you, the Four of you, for trusting me beyond doubt. Up to you now!

Thank you, Agnès and Paco, for your unfailing support throughout our Portuguese adventures.

And thank you all, dear Partners: Cassandre, my trusted pair, Simon, you know, Max, Sofia, Irina, Athé, Ana, Léo… Thanks for letting me join your work, basketball, darts teams… with more or less success! It was a real pleasure to come back to University with you all. Have a beautiful and long journey!

Resumo

Objetivo: O objetivo deste trabalho é a realização de uma revisão da literatura publicada sobre as próteses adesivas na região anterior, de modo a avaliar as taxas de sobrevivência em função do material e do design.

Métodos: Efetuou-se uma pesquisa eletrónica na PUBMED/MEDLINE para identificar os artigos que relatam a longevidade das pontes adesivas anteriores, de 2000 a 2020. Apenas estudos clínicos primários com um follow-up mínimo de 3 anos foram incluídos. Em seguida, foi realizada uma análise estatística para avaliar a taxa de sobrevivência das próteses adesivas, dependendo do material e design.

Resultados: A revisão incluiu finalmente 26 artigos: estudos prospetivos, estudos retrospetivos, ensaios controlados aleatórios. A análise estatística reportou uma taxa de sobrevivência estimada, aos 5 anos, de 86,2% para as próteses metálicas, de 89,1% para zircónio, de 92% para alumina, de 100% para vitrocerâmica, de 81,7% para resina composta reforçada. A taxa de insucesso não foi significativamente diferente entre os grupos de materiais, nem entre os grupos de design.

Conclusão: As próteses adesivas apresentam uma excelente longevidade clínica aos 5 anos no sector anterior, com uma relação benefício/risco/custo favorável. Atualmente não existe consenso quanto a um material ideal. O design do cantiléver tende a limitar os constrangimentos aos retentores, aumentando assim o tempo de sobrevivência das próteses. As pontes cantiléver em cerâmica podem ser consideradas como uma terapia definitiva. Trata-se de uma solução adequada para adolescentes ou adultos jovens com potencial de crescimento contínuo.

Palavras-chave

resin-bonded ; bridge ; cantilever ; fixed dental prostheses ; survival rate

Abstract

Objectives: This study aimed to review clinical publications involving resin-bonded fixed partial denture in the anterior region, to evaluate their survival rates as a function of material and design.

Methods: An electronic search was conducted in PUBMED/MEDLINE to identify all articles reporting on the longevity of anterior resin-bonded bridges from 2000 to 2020. Only primary clinical studies having a minimal follow-up of 3 years were included in this review. Then, a statistical analysis was performed to evaluate the survival rates of the resin-bonded fixed dental prostheses, depending on material and design.

Results: The review finally included 26 clinical publications: prospective studies, retrospective studies, and randomized controlled trials. The statistical analysis indicated an estimation of the 5-year survival rate to be 86,2% for metal-framed, 89,1% for zirconia, 92% for alumina, 100% for glass-ceramics, 81,7% for fibre-reinforced composite bridges. The failure rate was not significantly different among the different material groups, neither among the single or double retainer groups.

Conclusion: Resin-bonded prostheses present excellent clinical 5-year longevity in the anterior sector, with a favourable benefit/risk/cost ratio. There is currently no consensus on an ideal material for these restorations. The cantilever design tends to limit constraints on the prosthesis retainers and thus increases their survival time. The all-ceramic cantilever bridges can be considered as definitive therapy, given the high success and survival rates. It is an optimal solution for adolescents or young adults with continuing potential growth.

Keywords

resin-bonded ; bridge ; cantilever ; fixed dental prostheses ; survival rate

Table of contents

CESPU
INSTITUTO UNIVERSITÁRIO
DE CIÊNCIAS DA SAÚDE

List of tables

List of figures

List of abbreviations

RBB(s)	:	Resin-Bonded Bridge(s)
RBFDP(s)	:	Resin-Bonded Fixed Dental Prosthesis(es)
FRC	:	Fibre-Reinforced Composite
MDP	:	10-Methacryloyloxydecyl Dihydrogen Phosphate
APC	:	Air particle abrasion / zirconia Primer / adhesive Composite resin

1.INTRODUCTION

The congenital absence of teeth is one of the most common developmental disorder[1]. It can have more or less severe aesthetics and functional repercussions on the stomatognathic apparatus: dental migration, bone resorption, impaired mastication. It was estimated that tooth agenesis affected 8% of a Portuguese population studied at Porto faculty of dentistry, with higher values for the mandible and no significant difference between male and female genders. The most frequently missing teeth, excluding third molars, were the mandibular second premolars (28.6%) and the maxillary lateral incisors (27.8%)[2]. On the other hand, the traumatic absence of teeth is highly frequent, especially in children and young adults. An observational study carried out on a randomized sample of 301 students, aged from 15 to 19 years, attending public secondary schools in Porto, reported a prevalence of dental trauma of 44.2%. The most affected teeth were the maxillary central incisors, especially in male pupils[3]. Thus, missing teeth in the anterior aesthetic region represent an ordinary reality for dentists, who must be able to deal with various treatment strategies, depending on the characteristics of patients (age, medical condition, economic resources). The aesthetic and social discomfort generated by an edentulous anterior zone often requires urgent care of patients. In young subjects, agile management of such situations is of increased importance, due to unfinished growth and consequent necessity to handle with the space created by this congenital or traumatic tooth loss.

Several therapeutic options are available to address the problem of unitary anterior edentulism: orthodontic space closure followed by dental recontouring, implant-supported single crowns, conventional fixed partial denture, adhesive denture, removable partial denture. Resin-bonded bridges have traditionally been part of this therapeutic arsenal since the 1970s. In 1973, Alain Rochette described a two-retainer bridge with a metal framework. The mechanical retention of the prosthesis relied on funnel-shaped perforations through the wings, to enhance resin retention. This type of bridge has gradually been abandoned due to the high number of debonding (limited adhesion and weakness of metal perforated retainers) and caries of the abutment teeth inherent in perforation of the retainer wings. Later on, the University of Maryland improved the retention of resin-bonded bridges through micromechanical retention of electrolytically etched-metal wings. A significant meta-analysis conducted by Pjetursson in 2008 estimated a 5-year survival rate of 87.7% for RBFPDs with metal frameworks[4]. Initially used as temporary restorations, resin-bonded bridges have benefited from the advances in dental materials in recent decades. In the early 1990s, Kern described the first all-ceramic resin-bonded bridge in particular to overcome the aesthetic problems associated with metal bridges in the anterior sector. After various tests on the ceramic type, on retainer design and number, on abutment teeth preparation, Kern stated in 2017 that "*all-ceramic cantilever RBFDPs provide an excellent minimally invasive treatment alternative to implants and conventional prosthetic methods when single missing anterior teeth need to be replaced*," with a 10-year survival rate of 98.2%[5].

In a period of advancing implantology, the therapeutic use of resin-bonded bridges is subject to scepticism on the part of practitioners, a fortiori when patients do not fall within the field of implant contraindications. The objective of this study is to carry out an integrative review of the published literature on the resin-bonded bridge survival rate in the anterior sector. Considering that the 5-year survival rate is estimated to 98.3% for metal-ceramic implant-supported single crowns and 97.6% for zirconia implant-supported single crowns[6], this review aims to find out if and how resin-bonded bridges can be a definitive alternative to implants in the treatment of anterior unitary edentulism.

Tab.1: PICOS search	
Participants	Patients with anterior partial edentulism
Interventions	Resin-bonded bridges to replace missing incisors or canines
Comparisons	-
Outcomes	Longevity (success and survival) of RBBs
Study design	Prospective and retrospective studies ; randomized-controlled clinical trials

2.OBJECTIVES AND HYPOTHESES

The purpose of this study was to review the literature about the survival rates of resin-bonded fixed dental prostheses in the anterior region, to gather clinical evidence of the influence of material and design on prosthesis survival. The null hypotheses tested were that the design of the bridge or material would not affect its longevity.

The secondary objectives of this study were to verify if the survival of anterior RBFDPs was comparable to that of unitary implants, and if that therapy could be considered as a definitive solution or only a temporary one.

3.METHODS

3.1 Search strategy

An electronic search was conducted in PUBMED/MEDLINE to identify all publications reporting on the survival rate of anterior resin-bonded bridges from January 2000 to March 2020. The following combination of keywords was used: "resin bonded" OR "ceramic bonded" AND bridge OR cantilever OR "fixed dental prostheses" OR "fixed partial denture" OR RBBs OR RBFDPs.

Two operators independently selected pertinent articles through their titles and abstracts, also relying on the following criteria of inclusion: primary clinical studies with a minimum of 3-year follow-up (prospective or retrospective studies, randomized clinical trials), English language, human subjects, abstracts available. Moreover, the item "related articles" of PUBMED, as well as the bibliographies of existing reviews, were used to identify more relevant references. Eventually, a list of 26 articles was established to extract data on the survival rates of anterior RBBs.

3.2 Statistical analysis

In the field of statistics, the success rate corresponds to the percentage of bridges still in situ after a certain number of years without any complication requiring the dentist's intervention. The survival rate is defined by the percentage of bridges still in place after a given number of years, with or without practitioner intervention and whatever its condition (fracture, mobility). The definition of success and survival rates may vary from study to study. Thus, in this review, to standardize the calculation of longevity, we considered that the success of the RBFDPs was defined as its presence in the mouth, in good conditions of function and aesthetics, without any intervention during the follow-up time. Events such as debonding, ceramic chipping of the pontic (even minors) were considered as triggers for the end of success. For example, a case of debonding, even followed by a successful rebonding, or a ceramic chip-off resolved by a polishing, was considered as a modification during the observation time, and consequently registered as a failure. This way of recording complications was chosen to allow a stricter comparison of studies, even though it is unfavourable to the final quantitative result of RBBs longevity.

To compare the clinical survival of the various cohorts, despite the different number of patients and follow-up time, the success rate of RBBs was calculated, from the basic data extracted, as follows: for each study, the total exposure time was calculated by multiplying the number of RBFDPs by the mean time of observation. A failure rate per year was then estimated, as a percentage, by the quotient of the number of failures observed over the total exposure time. Finally the 5-year success rate, or the 3-year success rate in case of shorter effective follow-up time, were respectively obtained by the following formula: 100 – 5*(failure rate per year) and 100 – 3*(failure rate per year), as shown in table 4.

These results were then statistically analysed to estimate the 5-year success rate per material and per design. Two ANOVA tests were run to check any statistically significant difference among groups.

4.RESULTS

4.1 Study selection

The initial electronic search gave 915 results, which were all screened manually by titles. 810 of them were rejected, and 105 were reviewed by abstracts. 37 were assessed as full-text articles. Out of these last 37, 26 studies were included in this review, and 11 were excluded for the following reasons: 1 in vitro study, 9 studies that focused mainly on posterior RBFDPs (premolars and molars), 1 cohort with a follow-up study already included in the selection[7].

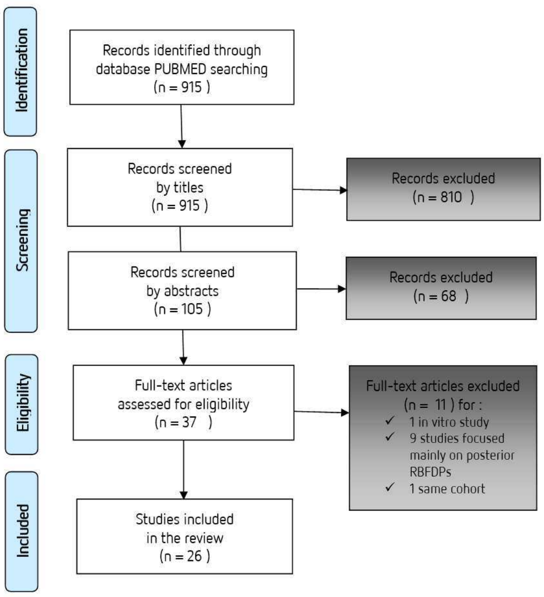

Fig.1 : PRISMA flow diagram for search strategy

4.2 Study characteristics

This systematic review includes 26 studies: 12 prospective studies[7–18], 11 retrospective studies[5,19–28], 1 mix of a prospective trial and a retrospective evaluation[29], and 2 randomized controlled trials[30,31]. It evaluates a total of 2469 patients with 1843 anterior resin-bonded bridges.

As for the 26 studies meeting the inclusion criteria, the following necessary data were extracted:

- Total number of RBFDPs in the anterior sector (incisors and canines/maxilla and mandible). This figure takes into account the number of patients with RBBs who gave up the cohort study during the follow-up time (cf. drop-out percentage in Table 2). In articles referring to both anterior and posterior bridges[12,20,23,24], only the RBBs located in the incisor/canine sector have been accounted for.
- Mean exposure time (in years)
- Number and reason for failures. The following two categories of events were defined as RBFDPs' failure :
  - ✓ Technical complications: debonding, bridge fracture, retainer fracture, pontic chipping, aesthetic complain;
  - ✓ Biological complications: caries, periodontal problems, tooth movement.
- Bridge material
- Bridge design (number of retainer(s))
- Preparation of the abutment tooth
- Bonding material

Tab.2 : Main characteristics of the 26 studies included in the review						
Year	Author	Type of study	Total # of patients	Mean age of patients	Drop out %	Total # of anterior RBBs
2018	Shahdad	prospective	26	NR	0	37
2017	Kern	retrospective	87	32	7	100
2016	Kern	prospective	16	33,3	0	22
2016	Botelho	prospective	28	50,5	21	23
2016	Klink	prospective	18	33	0	23
2016	Tanoue	prospective	226	NR	NR	85
2015	King	retrospective	805	NR	23	552
2015	Kumbuloglu	prospective	134	42	0	175
2014	Botelho	retrospective	153	55,4	NR	111
2014	Saker	randomized	40	36,1	0	40
2014	Galiatsatos	prospective	49	NR	0	54
2014	Sasse	prospective	37	32,7	0	42
2014	Sailer	retrospective	15	27,5	0	15
2013	Lam	retrospective	78	NR	0	32
2013	Sasse	randomized	25	33,3	0	30
2013	Spinas	prospective	30	15	0	32
2013	Younes	retrospective	37	32,2	32	24
2013	Sailer	retrospective	40	NR	30	20
2013	Sun	prospective	35	42,1	0	35
2012	Boening	retrospective	44	22	21	56
2011	Kern	prospective	30	NR	0	38
2009	Vanheumen	mix prospective trial / retrospective evaluation	52	35	27	46
2008	Aggstaller	prospective	184	NR	64	84
2006	Garnett	retrospective	45	17,6	43	73
2005	Chai	retrospective	168	NR	36	33
2000	Corrente	retrospective	67	42,1	NR	61
	TOTAL	-	2469	-	-	1843

Tab.3 : Bridge material & design – Bonding material				
Year	Author	Bridge Material	Bridge Design	Bonding Material
2018	Shahdad	ZIRCONIA (CADCAM)	ONE RETAINER	MULTILINK AUTOMIX
2017	Kern	ZIRCONIA (CADCAM)	ONE RETAINER	PANAVIA 21 TC MULTILINK AUTOMIX ZIRCONIA PRIMER
2016	Kern	IN CERAM ALUMINA (14) IN CERAM ZIRCONIA (8)	ONE RETAINER	PANAVIA 21 TC
2016	Botelho	METAL veneered with ceramic	ONE RETAINER (13) TWO RETAINERS (10)	PANAVIA EX PANAVIA 21
2016	Klink	ZIRCONIA	ONE RETAINER	MULTILINK (22) VARIOLINK (2)
2016	Tanoue	METAL veneered with ceramic	TWO RETAINERS > TWO RETAINERS	SUPERBOND PANAVIA

Tab.3 : Bridge material & design – Bonding material

Year	Author	Bridge Material	Bridge Design	Bonding Material
2015	King	METAL veneered with ceramic	DIFFERENT DESIGNS	PANAVIA 21 TC
2015	Kumbuloglu	FIBER REINFORCED COMPOSITE	TWO RETAINERS	VARIOLINK MULTILINK RELY X BIFIX DC
2014	Botelho	METAL veneered with ceramic	ONE RETAINER	PANAVIA EX PANAVIA 21
2014	Saker	METAL Cr-Co ALLOY(20) IN CERAM ALUMINA (20)	ONE RETAINER	PANAVIA 21 TC
2014	Galiatsatos	IN CERAM ALUMINA	TWO RETAINERS	VARIOLINK II
2014	Sasse	ZIRCONIA (CADCAM)	ONE RETAINER	PANAVIA 21 TC
2014	Sailer	ZIRCONIA (CADCAM)	ONE RETAINER	PANAVIA 21 TC
2013	Lam	METAL veneered with ceramic	ONE RETAINER	adhesive resin cement
2013	Sasse	ZIRCONIA (CADCAM)	ONE RETAINER	PANAVIA 21 TC (16) MULTILINK AUTOMIX (14) ZIRCONIA PRIMER
2013	Spinas	FIBER REINFORCED COMPOSITE	TWO RETAINERS	PERMAMIX
2013	Younes	METAL veneered with ceramic	TWO RETAINERS	PANAVIA EX PANAVIA 21
2013	Sailer	GLASS CERAMIC EMAX	ONE RETAINER	TETRIC CERAM RELY X PANAVIA F HFO VARIOLINK
2013	Sun	GLASS CERAMIC EMAX	ONE RETAINER	VARIOLINK
2012	Boening	METAL veneered with ceramic	TWO RETAINERS > TWO RETAINERS	PANAVIA EX PANAVIA 21
2011	Kern	IN CERAM ALUMINA	ONE RETAINER (22) TWO RETAINERS (16)	PANAVIA 21 TC (22) PANAVIA TC (16)
2009	Vanheumen	GLASS FIBER REINFORCED COMPOSITE	TWO RETAINERS	COMPOLUTE VARIOLINK TWINLOOK PANAVIA
2008	Aggstaller	METAL veneered with ceramic	DIFFERENT DESIGNS	MICROFILL PONTIC
2006	Garnett	METAL veneered with ceramic	ONE RETAINER (62) TWO RETAINERS (11)	COMPOLUTE VARIOLINK TWINLOOK PANAVIA
2005	Chai	METAL veneered with ceramic	ONE RETAINER (18) TWO RETAINERS (15)	PANAVIA PANAVIA EX PANAVIA 21
2000	Corrente	METAL veneered with ceramic/resin	TWO RETAINERS	PANAVIA EX

4.3 Results of individual studies

The 5-year estimated success rate, or the 3-year success rate in case of shorter effective follow-up time, was calculated for each study according to the statistical method described previously in 2.2.

Tab.4 : Estimated success % after 5 years (* % after 3 years)

Year	Author	Total # of anterior RBBs	Mean follow-up time (years)	# of failures	Total RBFPD exposure time	Estimated failure rate (%/year)	Estimated success after 5 years (%)
2018	Shahdad	37	3	8	111,0	7,21	78,38*
2017	Kern	100	7,7	6	768,3	0,78	96,10
2016	Kern	22	15,6	2	343,2	0,58	97,09
2016	Botelho	23	18	9	414	2,17	89,13
2016	Klink	23	3	4	69	5,80	82,61*
2016	Tanoue	85	13,9	NR	NR	NR	90,28
2015	King	552	13	92	7176	1,28	93,59
2015	Kumbuloglu	175	5	13	875	1,49	92,57
2014	Botelho	111	9,4	10	1043,4	0,96	95,21
2014	Saker	40	2,8	5	113,3	4,41	86,76*
2014	Galiatsatos	54	8	9	432	2,08	89,58
2014	Sasse	42	5,2	3	218,4	1,37	93,13
2014	Sailer	15	4,4	2	66,6	3,00	90,99*
2013	Lam	32	9,6	7	307,2	2,28	88,61
2013	Sasse	30	5,3	2	160,5	1,25	93,77
2013	Spinas	32	5	2	160	1,25	93,75
2013	Younes	24	16	10	NR	1,49	92,56
2013	Sailer	20	6	0	120	0,00	100,00
2013	Sun	35	3,9	0	135,8	0,00	100,00*
2012	Boening	56	6,3	8	352,8	2,27	88,66
2011	Kern	38	19	8	722	1,11	94,46
2009	Vanheumen	46	5	30	230	13,04	34,78
2008	Aggstaller	84	6,3	11	529,2	2,08	89,61
2006	Garnett	73	4,9	32	357,7	8,95	55,27
2005	Chai	33	5,0	6	165	3,64	81,82
2000	Corrente	61	6,7	13	408,7	3,18	84,10
	TOTAL	1843		292			

4.4 Synthesis of results

A total of 1843 anterior resin-bonded bridges was studied in this review, 1154 (62,6%) being of metal framework and 689 (37,4%) of non-metal framework (ceramic or fibre-reinforced composite). As regards the bridge design, various configurations were found in the included studies. We focused on the number of retainers : one retainer, i.e. cantilever design ; two retainers ; more than two retainers. It was possible to assess the exact number of bridge designs in the incisor/canine sector for 23 studies representing 1137 resin-bonded anterior bridges : 622 are cantilevered bridges (54,7%), 511 have two retainers (44,9%) and 4 have more than two retainers (0,4%).

Survival rate and Bridge material & design

Following the statistical method presented in 2.2, the estimated 5-year success rates are as follows (Table 5): 86,2% (SD=10,9 SE=3,3) for the metal framework RBFPDs, 89,1% (SD=7 SE=2,9) for zirconia, 92% (SD=3,4 SE=2,4) for In-Ceram alumina, 100% for glass-ceramics and 81,7% (SD=19,9 SE=11,5) for fibre-reinforced composite. The framework material did not have a statistically significant effect on the longevity of RBBs (P=0,42).

Considering all the relevant studies of this review, the cantilever bridge showed better 5-year longevity than the 2-wing bridge, respectively 91,8% and 85,2%. However, the failure rate was not statistically significant among both groups (P=0,17).

Tab.5 : Estimated success rate by bridge material & design			
5-year success rate			
by framework material		*by number of retainers*	
Metal	86,2%	one retainer	91,8%
Zirconia	89,1%	two retainers	85,2%
In-Ceram alumina	92%		
Glass-ceramics	100%		
FR Composite	81,7%		

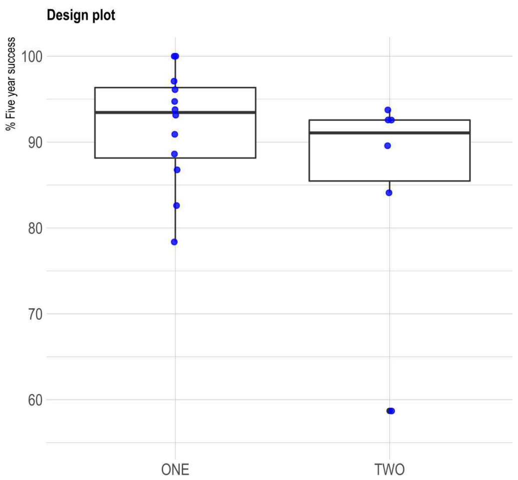

Fig.2: Estimated success rate vs Bridge design

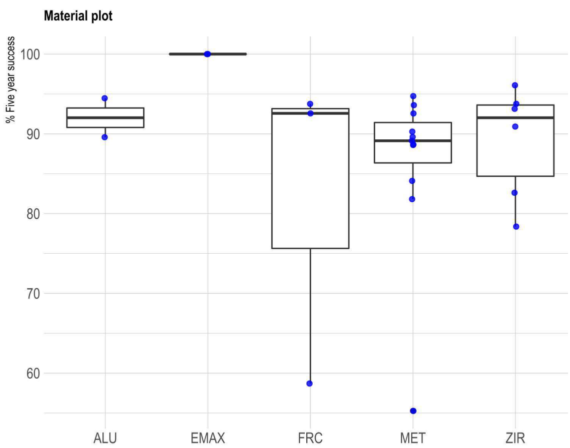

Fig.3: Estimated success rate vs Bridge material

This review includes several studies based on the comparison of bridge design. In three comparative studies, RBBs with metal framework demonstrated a significantly better success and survival when designed with a single retainer rather than with two retainers[10,17,19]. Cantilever bridges also showed higher results in terms of biological complications: "*no abutment tooth was lost or endodontically involved*"[10]. The performance of single-retainer prostheses was attributed to the avoidance of differential movement of the abutment teeth[19], evidenced in 2-winged bridges. The longevity of all-ceramic RBFDPs is largely affected by the design of the restoration. When comparing glass-infiltrated alumina ceramic bridges, Kern observed a 10-year survival rate of 73.9% in the two-retainer group and 94.4% in the single-retainer group[17]. On the other hand, two studies did not observe any statistically significant difference in success when modifying the bridge design[12,27].

As regards of framework material, one study compared traditional metal-ceramic (cobalt-chromium-ceramic) and all-ceramic (glass-infiltrated alumina In-Ceram) bridges, and concluded that the difference in the survival rate of cantilevered metal-ceramic and all-ceramic bridges was not significant[30]. Several authors used zirconia (IPS e.max ZirCad veneered with IPS e.max Ceram), and one study tested different zirconia materials. Other investigators decided to choose other types of all-ceramic materials: glass-infiltrated alumina [9,14,17]and lithium disilicate ceramics e.max[16,23]. Mean survival rates for each type of material are summarized in table 5. No statistically significant effect of the framework material was demonstrated in this review.

All studies agreed to conclude that resin-bonded FDPs, and especially cantilevered all-ceramic bridges, have promising clinical survival and functional longevity in the anterior upper and lower sector. The survival rates, defined as the presence of the prosthesis in situ at the end of follow-up time, with or without intervention, were high in most studies of this review and are summarized in Table 6.

Tab.6 : Survival rates of RBFDPS			
Study	**Design, Material of the bridge**	**Follow-up**	**Survival rate**
Kern 2017	cantilever, zirconia	10 years	98,2%
Kern 2016	cantilever, In-Ceram alumina & In-Ceram	10 years	95,4%
Kern 2016	cantilever, In-Ceram alumina & In-Ceram	18 years	81,8%
Botelho 2014	cantilever, metal cast	9,4 years	90%
King	multiple designs, metal cast	10 years	80,4%
Galiatsos	2 retainers, In-Ceram alumina	8 years	85,2%
Sasse 2014	cantilever, zirconia	6 years	100%
Sailer 2013	cantilever, glass-ceramics e.max	6 years	100%
Kumbuloglu	2 retainers, fibre-reinforced composite	5 years	97,7%
Sun	cantilever, glass-ceramics e.max	4 years	100%
Sailer 2014	cantilever, zirconia	4 years	100%
Sasse 2013	cantilever, zirconia	3 years	100%
Saker	cantilever, all-ceramic / cantilever, metal-	3 years	90% / 100%
Klink	cantilever, zirconia	3 years	100%

However, three studies showed more contrasting results with significantly lower survival rates: Vanheumen (2 retainers, fibre-reinforced resin composite)[29], Garnett (multiple designs, metal cast)[26] , and Tanoue (multiple designs, metal cast)[12].

Complications

It was possible to extract data on the number of complications encountered during patient follow-up in 25 of the 26 studies. This review reports 292 complications after resin-bonded bridge placement in the anterior sector. 23 articles reported the nature of the complications. Thus, out of the 268 failures precisely identified in this review, 257 (95,9%) were of a technical nature and 11 (4,1%) of a biological nature. Figure 4 gives an overview of the results in terms of complications after RBB placement.

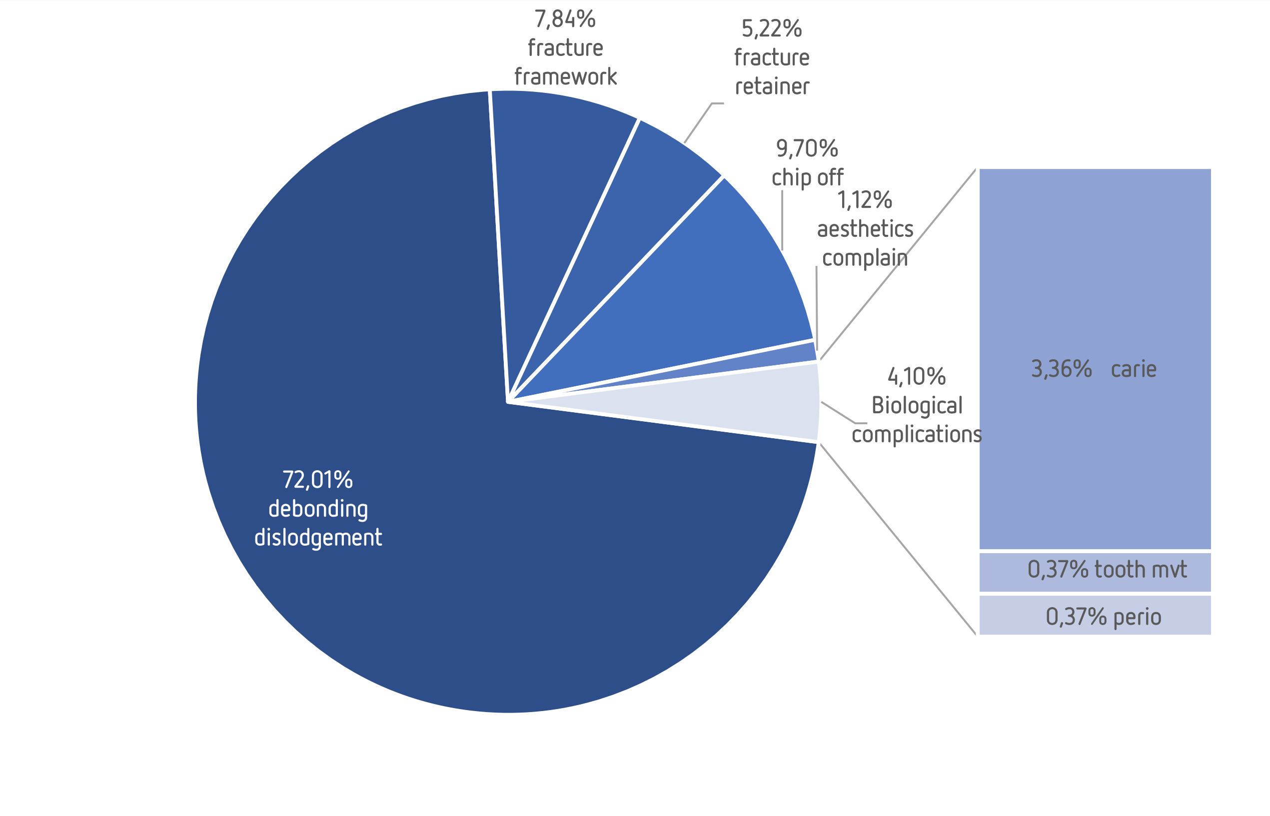

Fig.4 : Technical and biological complications observed during the follow-up time

Debonding remains by far the most common reason for the failure of resin-bonded bridges. RBBs with metal frameworks seem to be the most concerned by this technical problem. In a long-term prospective study (18 years of mean follow up time), Botelho observed that debonding was the only source of the failure of metal framework RBFDPs used to replace missing maxillary incisors. However, the retention rate was highly influenced by the bridge design as 100% of cantilever bridges survived without any complications, whereas only 50% of 3-units survived and 10% without intervention[10].

As for fibre-reinforced composite fixed dental prosthesis, Kumbuloglu related that "*experienced failures in general were due to debonding of the restoration or delamination of the veneering composite*"[13]. However, almost all complications were minor, and after the intervention of a practitioner, initial prostheses (except one) remained in function until the end of the 4,8-year follow-up time. Finally, the author stated a survival rate of 97,7% for composite 3-unit RBBs.

In the field of ceramic prostheses, Kern reported 6 debondings (out of 7 total failures) of anterior zirconia ceramic RBBs. This figure has to be moderated by the fact that 3 debondings were due to traumas and that all 6 restorations could have been rebonded without any further difficulties. Kern claimed that "z*irconia ceramic RBFDPs yielded a 10-year survival rate of 98.2%*" and, "*when debonding was considered a complication, the success rate (survival with complication) was 92.0% after 10 years*"[5]. As regards glass-ceramics cantilever bridges, Sun and Sailer both achieved a 4-year success rate of 100% with no debonding recorded[16,23].

Abutment tooth preparation

Resin-bonded bridges are considered as a biologically conservative treatment of unitary edentulism. They require a minimally invasive preparation and, thus, constitute a reversible treatment. Depending on whether the RBBs are seen as a provisory or a permanent restoration, the preparation of the abutment teeth will be carried out or not. However, regardless of this last consideration, this literature review highlights several visions of what a dental preparation should be before the placement of a resin-bonded bridge. The majority of studies refer to the creation of grooves, pits, slots, chamfers, proximal boxes on the lingual/palatal face of the abutment teeth, to secure the seating and retention of the prostheses[5,7,9–11,16,17,21,22,27,30,31]. While a few authors have opted for a "no preparation" option[8,23], the majority agree on the benefits of a minimal preparation without penetration into dentine, with a supragingival finish line and allowing an adequate bonding surface to the material chosen for the prosthesis. King reported a two-fold increase in failure when the preparation exceeded the enamel[19].

On the other hand, several protocols for the surface treatment of the prosthesis before bonding are described in the publications: alumina air-abrasion, tribochemical silica-coating, etching with hydrofluoric acid, silanization, ultrasonic cleaning, metal primers, zirconia primers.

Patient outcomes

Patient satisfaction following rehabilitation in the aesthetic zone with anterior RBBs was assessed in 4 studies included in this review. Botelho estimated that "*95.2 percent of patients were satisfied with the aesthetics of the prostheses, and patient satisfaction with the overall prosthesis experience was also high*"[10]. When comparing two-unit (CL2) and three-unit (FF3) resin-bonded fixed partial dentures, the author found no significant difference in satisfaction and oral health-related quality of life between the 2 groups whose study subjects were generally satisfied with the performance and treatment procedure of RBFPDs. Nevertheless, the CL2 patients were more positive with the cleaning of their prostheses, which allow the use of dental floss in the interproximal areas. Likewise, King concluded that "*the majority of patients rated the function of their restorations as good*"[19]. The cases of only "satisfactory" appearance of the bridge were linked to the display of the cervical margin of the metallic framework or the grey effect it could give to the abutment tooth. After a few trials, King solved this problem by using an opaque variety of resin luting cement. As for all-ceramic resin-bonded bridges, Sun evaluated the patient satisfaction with the aesthetic and functional outcomes of their restoration at the final follow-up, after a mean of 46,57 months[16]. Patients were asked to register their satisfaction on a Visual Analog Scale (VAS) from 0 (very dissatisfied) to 100 (very satisfied), a score superior to 80 being considered as a high degree of satisfaction. The VAS in this study reached a score of 87,5, which demonstrates an adequate response of the IPS e.max cantilevered bridges to the patients' expectations.

Dentist experience

In this review, 4 studies consider the experience of the operator as a significant factor associated with RBBs' success. King showed that "*for bridges provided by staff or postgraduate students, the survival rate was just over double that of undergraduate students*" [19]. Tanoue also concluded that "*the risk of failure [...] of inexperienced dentists was 2.0 times greater than that of dentist experienced and specialized in adhesive dentistry*"[12]. Botelho explained that statistical analysis showed a longer service life of prostheses placed by full-time staff than students, even though the difference was not significant between both groups as regards the debonding rate specifically[21]. Finally, Garnett drew the same conclusions, reporting a risk of failure 3.9 times greater with junior staff and 2.5 times higher with supervised students[26].

Various clinical factors

The publications included in that review also refer to various criteria considered as relevant or irrelevant for the RBFDPs clinical success :

- ***Patient age at insertion*** : Tanoue considered it as significant and claimed that "*the risk of failure in younger patients (age ≤ 56) was 1.7 times greater than that in older patients (age > 56)*"[12]. This difference was mainly attributed to the higher risk of trauma in the young population. On the contrary, King stated that patients under the age of 30 showed a lower failure rate than those over 30 (respectively 13,7% and 24,2%)[19].

- *Location Maxilla/Mandible* : A large majority of the studies reported that the upper or lower location of the RBBs did not statistically affect its longevity[7,8,12,18,19,21,24].
- *Bonding system* : The authors refer to various types of cement, PANAVIA EX and PANAVIA 21 from Kuraray being the most commonly used. This review did not allow for the conclusion that one cement is superior to another. Sailer used 6 different cements for anterior and posterior single retainers and after 5 years, the survival rate of the RBBs was 100% without debonding[23]. Klink used Variolink and Multilink as cement, and the survival rate was also 100% in both cases[11]. Kumbuloglu evaluated the performance of 4 resin cements in the clinical survival of anterior 3-unit fibre-reinforced composite fixed dental prosthesis. He found that "*the survival rates with the four resin cements did not show significant differences (RelyX ARC: 98.3%; Bifix DC: 93.5%; Variolink 2: 100%; Multilink: 100%)*"[13]. As for ceramic bridges, Sasse compared a phosphate monomer containing resin (Panavia 21 TC) and an adhesive bonding system with a phosphoric acid acrylate primer (Multilink—Automix with Metal/Zirconia primer). He also concluded that there was no significant difference between the two bonding systems[31]. Finally, Tanoue related no significant difference in the restoration survival in relation to cement type (a methyl methacrylate-based self-curing resin : Super-Bond from Sun Medical co; and a composite luting agent : Panavia EX, Panavia 21 or Panavia F2.0 from Kuraray)[12]. On the other hand, very heterogeneous success rates have been observed for the same cement in Chai and Garnett studies, which might be explained by the dentist experience[26,27]. Similarly, a same cement, e.g. Panavia, shows better results for metal or zirconia bridges than for glass-infiltrated alumina ceramic RBBs.
- *Occlusal factors & parafunctional habits* : Garnett classified the studied subjects into 3 groups in relation with the pontic contacts (no contact/contact with the pontic in the intercuspal position/contact with the pontic only in a lateral or protrusive movement). It was not possible to show any significant difference between the 3 groups. Likewise, "*there was no statistical significance between the presence and absence of a parafunctional habit [either clenching or grinding, nail-biting or pen chewing] and survival ($p = 0.72$)*". Meanwhile, the same study put its results into perspective and concluded that "*occlusal factors and parafunctional activity may be important in the*

success and failure of a RBB"[26]. Indeed, an almost statistically significant improvement noticed for the bridges with a contact in the intercuspal position, may be explained by the fact that these had been placed by more experienced dentists. For his part, Klink claimed that the "*success depends on dynamic occlusal relation*"[11]. King also reported that the presence of contacts in excursions of the pontic was significantly associated with a higher failure rate. In contrast, the presence of contacts in excursions of the abutment was not significantly associated with the longevity of resin bonded bridges[19].

- *Rubber dam use* : The importance of moisture control through rubber dam during the insertion of RBFDPs is sometimes referred to, but the use of a rubber dam is not always documented in the studies. For example, Garnett referred to "*insufficient cases in both situations [presence or absence of rubber dam] for meaningful analysis*"[26]. At the Bristol Dental Hospital, King reported a significantly higher success of RBBs placed with rubber dam[19]. More recently, rubber dam has not anymore been considered as an optional clinical factor, but as a mandatory part of the process of insertion of the restoration. Thus the most recent studies do not consider the presence or absence of rubber dam as a relevant topic of study.

5.DISCUSSION

This review of dental literature about RBFDPS in the anterior zone showed that this type of prosthesis had demonstrated successful clinical results and patient satisfaction. It allows dental practitioners to meet one of their main objectives, which is tissue preservation, especially in young patients. The current trend is clearly to shift towards all-ceramic restorations to the detriment of RBBs with a metal framework. Recently, more favourable survival rates were related to the cantilevered design of resin-bonded bridges.

5.1 In search of the ideal material

Since the early '90s, the dental school of Hong Kong has been considering this kind of restorations as a standard therapeutic means to be offered to patients. Botelho and Lam published various long-term studies reporting high survival of Ni-Cr RBBs and also exposed reasons for preferring cantilever bonded bridges to implant-supported restorations. They highlighted, from a case series of 78 patients, fewer biological complications on cantilever bonded bridges (7.7%) than on implant-supported crowns (25.6%)[20]. However, their conclusion was qualified by the fact that longer-term follow-up studies, up to 10 years, would be necessary to validate the real predominance of RBB over the unitary implant in the anterior sector.

Besides, a survey showed that 94,4% of the questioned dentists described themselves as 'confident' or 'very confident' in the provision of metal cantilever resin-bonded bridges[32]. However, from the patient's perspective, metal-based restorations may generate aesthetic problems due to the greyish shine through metal, which is particularly annoying in the anterior zone. Moreover, allergenic, corrosive, even mutagenic effects of certain non-precious metals have been evoked. All of this has led to a search for change and improvement in materials used for resin-bonded bridges.

In recent years, within the modern adhesive dentistry shift, the trend is towards the use of ceramics, a highly biocompatible material that requires preparations that are less mutilating than for metal. The first attempts of all-ceramic RBBs were initially based on the 2-wing design. Numerous unilateral debondings and connectors fractures have been observed. Such technical complications have been explained by the absence of plastic deformation potential of ceramics (brittle material) and have led to further studies with a cantilevered design of all-ceramic RBBs to overwhelm this issue. The University of Kiel, with Kern and Sasse, has stated a 10-year survival of the cantilever group (zirconia or alumina infiltrated ceramic) of 94.4% compared to that of the 2-wing group which is 67.3%. Kern also stated that zirconia ceramic RBFDPs reached a 10-year survival rate of 98.2%, without any influence of the reasons for missing teeth (trauma, agenesis)[5]. By replacing alumina by zirconia ceramics and by changing the bonding system (Multilink automix Ivoclar with zirconia primer), Sasse even achieved a survival rate of 100% after 3 years[7]. The University of Geneva also focused on all-ceramic anterior RBBs, and Sailer mentioned successively a 100% survival rate after a 4-year follow-up of 15 zirconia bridges and also after a 6-year study of 35 glass-ceramics (Empress and Emax Ivoclar) RBFDPs[22,23].

By the way, the use of glass-ceramics seems to be promising[16]. French practitioners Tirlet and Attal also defended the choice of glass-ceramics in relation to better optical properties and better bonding potential than infiltrated ceramics like zirconia[33]. The relative weakness of the mechanical properties of glass-ceramics compared to infiltrated ceramics leads practitioners to consider a larger connection area on the abutment tooth. It should be noted, however, that the high bonding properties of glass-ceramics significantly optimized the final mechanical resistance of all-ceramic RBFDPs. A recent in vitro study concluded that *"Lithium disilicate cantilever RBFDP had comparable fracture strength to metal-ceramic RBFDP and had a significantly higher fracture strength than the zirconia RBFDP"*[34]. Further long-term clinical studies are needed to validate this assumption about the use of glass-ceramics.

5.2 Reasons for a cantilever design

According to the Roy principle stated in 1927 about periodontal splints, the teeth bordering the edentulous area have differential physiological mobility. The preferential axis of mobility (Fig.5) differs by the three groups of teeth: the incisive group moves in the sagittal plane, the premolar/molar group shifts in the frontal plane, and the canine group goes in the bisector plane of the two previous ones. These differential micro-movements create stresses in the retainers of the RBFDPs. To limit such constraints, it was considered to design prosthesis with a single axis of mobility.

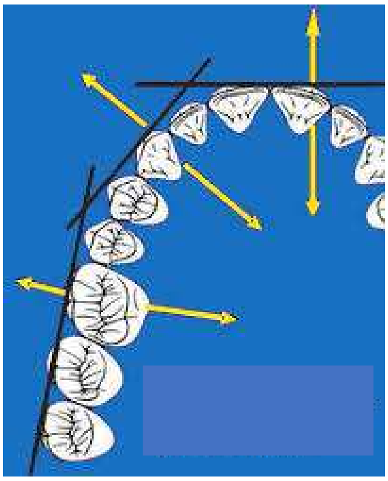

Fig.5 : Physiological axis of dental mobility

The University of Honk Kong refers to the use of cantilever RBFDPs as far back as 1992. These bridges are supported by a single abutment tooth and span the gap left by the adjacent missing tooth. In cases of replacement of a single anterior tooth, the superiority of the 2-unit design over the 3-unit design seems to be explained by the differential movements of the two abutment teeth, which stress the bonding surface of the 3-unit bridges. This shear force might eventually cause the debonding of the retainers, usually the one on the abutment tooth with the least physiological mobility. Obviously, with only one support tooth, such inter-abutment stress is not possible in cantilever bridges[7,10,30].

These results were confirmed in vitro by the same study team in Hong Kong[35]. The purpose was to compare the fatigue bond strength of 3-unit versus 2-unit RBFDPs after cycles of high and repeated loads on abutment analogs, simulating the repetitive dynamic loading experienced by prosthetic restorations during mastication or parafunction. In order to closely simulate both types of bridges, cast metal frameworks were cemented to metal tooth analogs capable of simulating periodontal movement. Within the limitation of such an in vitro study, the cantilevered design showed a significantly higher bond strength than both tooth analogs of the fixed-fixed framework (Table 7).

Tab.7 : Bond strength vs Bridge design

Prosthesis Design	Median Strength (N)
2-unit (cantilever)	421
3-unit loaded tooth analog	332
3-unit unloaded tooth analog	333

The cantilever design is appropriate when occlusal constraints are low and also when the stability of the abutment tooth is controlled. Thanks to periodontal mechanoreceptors, proprioceptors, and pain receptors, patients may unconsciously influence the magnitude of occlusal loads on abutment teeth. When the patient requests the pontic for occlusion, he perceives certain mobility, thanks to the periodontal proprioceptors of the supporting tooth. This encourages him to restrain occlusal loads, thus contributing to better longevity of the prostheses. In comparison to 3-unit bridges, cantilever RBBs exhibit decreasing periodontal ligament area of the abutments and thus decreasing occlusal stress on the pillar. As regards tooth mobility, King favoured the 2-unit RBBs over the 3-unit ones when the upper central incisor teeth had been orthodontically approximated. It has been demonstrated that when the orthodontic movement had been performed before the placement of resin-bonded bridges, the number of failures was higher. However, "*if space had been retained for at least three months,* *the median survival time can be significantly increased*"[19]. The 2-unit design allows a limited potential for orthodontic relapse and avoids the need for extra fixed orthodontic retention.

In a nutshell, although the use of cantilever bridges still arouses scepticism among some professionals, this design is proving to be less invasive and more cost-effective. Furthermore, the unidirectional mobility of the abutment tooth, as well as the patient's finer proprioception, are two elements that tend to limit constraints on the retainers of RBFDPs and thus increases their survival time.

5.3 Clinical implementation of the ceramic cantilever resin-bonded bridge

Choice of the abutment tooth

The choice of the cantilever bridge abutment will be made according to occlusal considerations and also according to the cementation requirements of the prosthesis. When replacing a lateral incisor, it is recommended to avoid leaning on the canine tooth. Indeed, this tooth is an essential pillar of occlusion during lateral movements. Moreover, the canine is located at the intersection of two radii of curvature of the dental arch and therefore focuses a large number of stresses. Then in teenagers, the canine is not always totally erupted and it is preferable not to bond the bridge to it. Finally, to face the risk of recurrence of tooth mobility after orthodontic treatment, the support on the canine is also not favourable because the possible opening of a diastema is less aesthetically compromising between the lateral and the canine than between the lateral and the central.

In the case of replacement of a central incisor, it is advisable to rest on the other central incisor, not on the lateral one. Indeed the palatal surface is larger and, therefore, more conducive to better bonding of the prosthesis. A light gingivectomy can be realized to optimize the bonding area. The lateral maxillary incisor also has a higher translucency compared to the central, and thus, for aesthetic reasons, it should not be chosen as an abutment. In the lower jaw, lateral incisors might be considered as a support for RBBs.

Ovate pontic design

To optimize the aesthetic integration of the adhesive bridge, which is especially important in the anterior region, it is recommended to ovalize the edentulous ridge. First described in 1933 by Dewey and Zugsmith, the ovate pontic is the most aesthetically appealing pontic design and is also the best profile from a biological point of view by facilitating oral hygiene. It consists of creating a soft tissue depression in the residual ridge to give the illusion that the pontic is emerging from the gingiva. The level of depth of the crestal ovalization is determined by the expected situation of the pontic to the line joining the central incisor neck to the canine neck (usually 1 mm below this line), in the case of a lateral incisor replacement. The tissues are carved in the shape of a crater with a round bur or a laser. Then, to help with a guided healing process of the edentulous ridge, a transparent gutter with a prosthetic resin tooth is placed in the mouth for 10 to 15 days.

Preparation of the abutment tooth

This literature review highlighted several ways of preparing the cantilever bridge support tooth. Minimal preparation and, therefore, maximum tissue preservation remains the main advantage of RBFDPs. From a "no preparation" principle to less conservative preparations, all studies agree on the following rules:

- A minimal preparation restricted to dental enamel
- A supragingival location to allow the bonding of the RBBs with the placement of a rubber dam
- A bonding surface sufficient for the retainer retention: at least 30mm2 of sound enamel[5]
- A material thickness calculated to prevent the risk of fracture and/or delamination.

Recent studies have proposed preparation designs for all-ceramic cantilever RBBs (zirconia and lithium disilicate-reinforced glass-ceramic)[5,33]. The design is defined as a veneer preparation on the palatal/lingual surface of the abutment tooth with the addition of elements such as chamfers, pinholes, or a box to stabilize the prosthetic component during insertion (Fig.6).

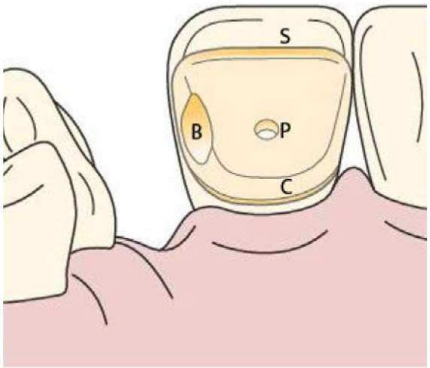

Fig.6 : Palatal preparation of the abutment tooth [5]

The critical elements of the abutment tooth preparation are described as follows :

- C : fine cervical chamfer with a rounded internal angle at the cervical level in the supragingival situation with a thickness of 0.6 to 0.8 mm in order to remain within the thickness of the enamel with the aim of optimal bonding.
- S : fine incisal finishing shoulder, whose limit depends on the translucency of the enamel margin. This line of translucency must not be exceeded and must not be undercut in order not to prevent the diffusion of light and alter the aesthetics. Nevertheless, its limit must be placed in such a way that it is possible to exploit the broadest possible palatal surface to optimize the bonding once again.
- B : small proximal box, opposite the edentulous area with an oblique orientation with respect to the major axis of the abutment tooth in order not to weaken the coronal edge during preparation or to modify the translucency. This connection box plays a major role in the durability and mechanical stability of the cantilever bridge. The proximal box must have an exact dimension, which must be at least 9mm2 for a zirconia bridge and 12mm2 for a lithium disilicate reinforced glass-ceramic prosthesis.
- P : small pinhole, centred on the cingulum for Kern and off-centre opposite the edentulous zone for Tirlet and Attal. This must be outside the pulpal area to prevent any risk of sensitivity. Its role is to ensure stabilization and retention of the bridge, primarily by preventing any risk of rotation.

An impression of the preparation is taken using a classic double mixing or "wash technique" with silicone.

The bite registration is performed in maximum intercuspal position. It is essential that any parafunction has been diagnosed and that the occlusal treatment has been completed and stabilized at this stage of the rehabilitation process.

Isolation and bonding

Once the operative field has been isolated with a rubber dam, once the positioning and adaptation of the bridge have been validated, the bonding will be carried out according to the protocol specific to the material chosen for the prosthesis. To obtain a strong and durable bond with high-strength ceramics (zirconia), several authors recommend compliance with the APC protocol[36].

- A: Air-particle abrasion of the bonding surface, through sandblasting or micro-etching with alumina or silica-coated alumina particles.
- P: zirconia Primer, containing adhesive phosphate monomer MDP, applied onto the zirconia bonding surfaces.
- C: adhesive Composite resin, dual or self-cure.

The treatment of a lithium disilicate-reinforced glass-ceramic bridge involves the application of 5% hydrofluoric acid followed by its neutralization in an ultrasonic bath with alcohol and acetone. A silane and an adhesive will then be applied. The bonding protocol on the abutment tooth begins with the sandblasting of the enamel (and dentine if exposed), followed by the application of an adhesive system (primer and bonding) with the prior etching of tooth surfaces with 37% orthophosphoric acid.

The cementation of an anterior cantilever bridge is a critical step. Indeed, a shift is possible between the incisal edges in the horizontal plane, but also the vestibular-palatal direction. This is due to the lack of stabilization of the bridge (only one retainer and minimal preparation of the abutment tooth), and also to the compression of the pontic in contact with the mucosa. To get around this difficulty, several practitioners recommend the use of a silicone key or splint to facilitate the proper positioning of the prostheses.

Finally, the patient should be instructed on how to clean the cantilever bonded bridge and the area underneath by passing a dental floss through the distal contact point. As far as checkups are concerned, the patient will have to come in every three months during the first year to check the prosthetic integrity and the clinical and radiological health of the abutment tooth. Once the first year has elapsed, an annual check-up appears to be sufficient.

5.4 Indications and contraindications

Historically, the indications and contraindications for resin-bonded bridges were detailed by Rochette in the 1980s. This therapy is suitable for the treatment of single-tooth edentulism in the anterior or posterior sector, and also of the edentulism of two mandibular incisors. RBBs can be used as a transitional prosthesis in young patients awaiting implant treatment or as a permanent prosthesis in patients with absolute contraindications to implant treatment. Rochette also describes its use in periodontal splints.

The generally accepted contraindications for this type of prosthetic restoration are as follows: diastemas which can prevent the aesthetic concealment of the connections; parafunctions; unfavourable crown/root ratio (>1); low coronal height; periodontal diseases; presence of enamel defects (imperfect amelogenesis/dentinogenesis, hypoplasia, demineralization) which may reduce the adhesive capacity; significant carious risk; extensive caries on the abutment teeth; class I with an extensive incisal overlay or class II.2 containing an overbite leading to occlusal overloading of the bridge; situations where isolation with rubber dam is not possible.

Currently, thanks to advances in restorative materials and bonding protocols, modern adhesive dentistry favours the use of cantilever bridges. Like its predecessors with 2 wings, it is a minimally invasive treatment for missing unitary tooth, effective even in cases of insufficient bone volume, with high survival rate, quick placement, excellent cost-effectiveness and high level of patient satisfaction. More specifically, the cantilever bridge is superior to the 2-wing bridge on the following points: possibility of all-ceramic prostheses with better aesthetics, better tissue preservation, better hygiene control, no unilateral debonding leaving a support tooth with an insulated wing and high risk of caries, no splint with a second adjacent tooth.

The all-ceramic cantilever resin-bonded bridge does present certain disadvantages, in particular, the lack of long-term clinical experience because of to its recent emergence. Due to the intrinsic properties of the material, zirconia prosthesis presents a risk of debonding (lower adhesive properties) and pulpal necrosis (infiltration due to mechanical overload of the joint).

The main drawback of the lithium disilicate bonded bridge is the fracture in the connection area.

According to the present review, the single-retainer resin-bonded bridge provided excellent clinical longevity, without any influence of the reasons for missing incisors (trauma, agenesis). It should be seen as a definitive restoration and not just as a provisional one pending implant treatment. However, various studies concluded that the cantilever bridge could be recommended for the anterior region only (central and lateral incisors). Its success has not yet been proven for the replacement of canines or premolars. As regards the posterior sector, a cantilevered all-ceramic RBB cannot be indicated.

6.CONCLUSION

Based on the publications included in this review, resin-bonded fixed dental prostheses present excellent clinical 5-year longevity in the anterior sector, when used for the right indications and according to the proper clinical procedures.

Current advances in dental materials and bonding systems have made it possible to use all-ceramic adhesive bridges to meet the aesthetic and functional demands of patients. However, there is currently no consensus on the ideal material for this type of restoration, and the choice of material (mainly zirconia or glass-ceramics) will depend on the clinical situation. The ceramic type will then determine the preparation of the abutment tooth and the selection of the bonding system.

The trend goes towards the use of all-ceramic cantilever bridges, which design tends to limit constraints on the retainers of RBFDPs and thus increases their survival time.

The estimated 5-year survival rate seems comparable but slightly less than that of the dental implant. However, the benefit/risk/cost ratio is more advantageous for the adhesive prosthesis solution than for the prosthetic implant solution.

Often defined as a medium-term temporary alternative, the all-ceramic cantilever RBBs can be considered as definitive therapy, given the excellent results on clinical survival. Furthermore, it is an optimal solution for adolescents or young adults with continuing growth potential. However, it is essential to note that this is a relatively new prosthetic solution, and further long-term studies are needed to confirm this assumption.

References

1. Kirac D, Eraydin F, Avcilar T, Ulucan K, Özdemir F, Guney A, Kaspar E, Keshi E, Isbir T. Effects of PAX9 and MSX1 gene variants to hypodontia, tooth size and the type of congenitally missing teeth. Cellular and Molecular Biology. 2016; 62(13):78-84.

2. Coelho A, Macho V, Andrade D, Augusto A, Areais C. Prevalence and distribution of tooth agenesis in a pediatric population: a radiographic study. RGO Revista Gaúcha de Odontologia (Online). 2012; 60(4):505–8.

3. Marinho ACMR, Manso MC, Colares V, de Andrade DJC. Prevalência de traumatismo dentário e fatores associados em adolescentes no concelho do Porto. Revista Portuguesa de Estomatologia, Medicina Dentaria e Cirurgia Maxilofacial. 2013; 54(3):143–9.

4. Pjetursson BE, Tan WC, Tan K, Brägger U, Zwahlen M, Lang NP. A Systematic Review of the Survival and Complication Rates of Resin-Bonded Bridges After an Observation Period of at Least 5 Years. Clinical Oral Implants Research. 2008;19(2):131-41.

5. Kern M, Passia N, Sasse M, Yazigi C. Ten-year outcome of zirconia ceramic cantilever resin-bonded fixed dental prostheses and the influence of the reasons for missing incisors. Journal of Dentistry. 2017; 65:51-55

6. Pjetursson BE, Valente NA, Strasding M, Zwahlen M, Liu S, Sailer I. A systematic review of the survival and complication rates of zirconia-ceramic and metal-ceramic single crowns. Clinical Oral Implants Research. 2018; 29 Suppl 16:199-214.

7. Sasse M, Kern M. Survival of anterior cantilevered all-ceramic resin-bonded fixed dental prostheses made from zirconia ceramic. Journal of Dentistry [Internet]. 2014; 42(6):660-3.

8. Shahdad S, Cattell MJ, Cano-Ruiz J, Gamble E, Gambôa A. Clinical Evaluation of All Ceramic Zirconia Framework Resin Bonded Bridges. The European journal of prosthodontics and restorative dentistry. 2018; 26(4):203–11.

9. Kern M. Fifteen-year survival of anterior all-ceramic cantilever resin-bonded fixed dental prostheses. Journal of Dentistry [Internet]. 2017; 56:133–5.

10. Botelho MG, Chan AWK, Leung NCH, Lam WYH. Long-term evaluation of cantilevered versus fixed–fixed resin-bonded fixed partial dentures for missing maxillary incisors. Journal of Dentistry. 2016; 45(2015):59–66.

11. Klink A, Hüttig F. Zirconia-Based Anterior Resin-Bonded Single-Retainer Cantilever Fixed Dental Prostheses: A 15- to 61-Month Follow-Up. The International Journal of Prosthodontics. 2016; 29(3):284-6.

12. Tanoue N. Longevity of resin-bonded fixed partial dental prostheses made with metal alloys. Clinical Oral Investigations [Internet]. 2016; 20(6):1329–36.

13. Kumbuloglu O, Özcan M. Clinical survival of indirect, anterior 3-unit surface-retained fibre-reinforced composite fixed dental prosthesis: Up to 7.5-years follow-up. Journal of Dentistry. 2015; 43(6):656–63.

14. Galiatsatos AA, Bergou D. Clinical evaluation of anterior all-ceramic resin-bonded fixed dental prostheses. Quintessence International. 2014; 45(1):9–14.

15. Spinas E, Aresu M, Canargiu F. Prosthetic rehabilitation interventions in adolescents with fixed bridges: A 5-year observational study. European Journal of Paediatric Dentistry. 2013; 14(1):59–62.

16. Sun Q, Chen L, Tian L, Xu B. Single-Tooth Replacement in the Anterior Arch by Means of a Cantilevered IPS e.max Press Veneer-Retained Fixed Partial Denture: Case Series of 35 Patients. The International Journal of Prosthodontics. 2013; 26(2):181–7.

17. Kern M, Sasse M. Ten-year survival of anterior all-ceramic resin-bonded fixed dental prostheses. Journal of Adhesive Dentistry. 2011; 13(5):407-10.

18. Aggstaller H, Beuer F, Edelhoff D, Rammelsberg P, Gernet W. Long-term clinical performance of resin-bonded fixed partial dentures with retentive preparation geometry in anterior and posterior areas. The journal of adhesive dentistry. 2008; 10(4):301-6.

19. King PA, Foster L v., Yates RJ, Newcombe RG, Garrett MJ. Survival characteristics of 771 resin-retained bridges provided at a UK dental teaching hospital. British Dental Journal. 2015; 218(7):423–8.

20. Lam WYH, Botelho MG, Mcgrath CPJ. Longevity of implant crowns and 2-unit cantilevered resin-bonded bridges. Clinical Oral Implants Research. 2013; 24(12):1369–74.

21. Botelho MG, Ma X, Cheung GJK, Law RKS, Tai MTC, Lam WYH. Long-term clinical evaluation of 211 two-unit cantilevered resin-bonded fixed partial dentures. Journal of Dentistry [Internet]. 2014; 42(7):778–84.

22. Sailer I, Hämmerle C. Zirconia Ceramic Single-Retainer Resin-Bonded Fixed Dental Prostheses (RBFDPs) After 4 Years of Clinical Service: A Retrospective Clinical and Volumetric Study. International Journal of Periodontics & Restorative Dentistry. 2014; 34(3):333–43.

23. Sailer I, Bonani T, Brodbeck U, Hammerle C. Retrospective Clinical Study of Single-Retainer Cantilever Anterior and Posterior Glass-Ceramic Resin-Bonded Fixed Dental Prostheses at a Mean Follow-up of 6 Years. International Journal of Prosthodontics. 2013; 26(5):443-50.

24. Younes F, Raes F, Berghe L van, de Bruyn H. A retrospective cohort study of metal-cast resin- bonded fixed dental prostheses after at least 16 years. European journal of oral implantology. 2013; 6(1):61–70.

25. Boening KW, Ullmann K. A retrospective study of the clinical performance of porcelain-fused-to-metal resin-bonded fixed partial dentures. International Journal of Prosthodontics. 2012; 25(3):265-9.

26. Garnett MJ, Wassell RW, Jepson NJ, Nohl FS. Survival of resin-bonded bridgework provided for post-orthodontic hypodontia patients with missing maxillary lateral incisors. British Dental Journal. 2006; 201(8):527–34.

27. Chai J, Chu FCS, Newsome PRH, Chow TW. Retrospective survival analysis of 3-unit fixed-fixed and 2-unit cantilevered fixed partial dentures. Journal of Oral Rehabilitation. 2005; 32(10):759–65.

28. Corrente G, Vergnano L, Re S, Cardaropoli D, Abundo R. Resin-Bonded Fixed Partial Dentures and Splints in Periodontally Compromised Patients: A 10-Year Follow-up. International Journal of Periodontics and Restorative Dentistry. 2000; 20(6):629–36.

29. Van Heumen CCM, van Dijken JWV, Tanner J, Pikaar R, Lassila LVJ, Creugers NHJ. Five-year survival of 3-unit fiber-reinforced composite fixed partial dentures in the anterior area. Dental Materials. 2009; 25(6):820–7.

30. Saker S, El Fallal A, Abo-Madina M, Ghazy M, Ozcan M. Clinical Survival of Anterior Metal-Ceramic and All-Ceramic Cantilever Resin-Bonded Fixed Dental Prostheses over a Period of 60 Months. The International Journal of Prosthodontics. 2014; 27(5):422-4.

31. Sasse M, Eschbach S, Kern M. Randomized clinical trial on single retainer all-ceramic resin-bonded fixed partial dentures: Influence of the bonding system after up to 55 months. Journal of Dentistry [Internet]. 2012; 40(9):783–6.

32. Patel PM, Lynch CD, Sloan AJ, Gilmour ASM. Treatment planning for replacing missing teeth in UK general dental practice: Current trends. Journal of Oral Rehabilitation. 2010; 37(7):509-17.

33. Tirlet G, Attal J-P. Les bridges collés cantilever en vitrocéramique renforcée au disilicate de lithium Raisons du choix et mise en œuvre clinique. Réalités Cliniques [Internet]. 2015; 26(3):35–46.

34. Gresnigt MMM, Tirlet G, Bošnjak M, Van der Made S, Attal JP. Fracture strength of lithium disilicate cantilever resin bonded fixed dental prosthesis: Ceramic cantilever RBFDPs. Journal of the Mechanical Behavior of Biomedical Materials [Internet]. 2020; 103:103615.

35. Wong TL, Botelho MG. The fatigue bond strength of fixed-fixed versus cantilever resin-bonded partial fixed dental prostheses. Journal of Prosthetic Dentistry. 2014; 111(2):136-41.

36. Blatz M, Alvarez M, Sawyer K, Brindis M. How to Bond Zirconia: The APC Concept. Compendium. 2016; 37(9):611-8.