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Self-Adhesive Resin Cements: A Clinical Review

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Abstract

Purpose: To review the performance of self-adhesive luting agents to determine their clinical evidence.
Materials and Methods: In March 2013, we conducted a literature search by means of PubMed and manually searched German and English medical journals using general search terms (e.g., "self-adhesive resin cements"), detailed search terms (e.g., clinical study "self-adhesive resin cement"), and brand name search terms (clinical study AND "brand name of the cement"). The resulting lists of articles were manually searched for clinical studies. Because of the low number of relevant articles, we decided to broaden our search by including in vitro studies based on a thermal cycling and mechanical loading (TCML) design.
Results: The search using the six general search terms yielded a list with over 100 studies with only 13 in vivo studies and 6 in vitro studies based on a TCML design. The other studies either did not comply with the requirements or were not in vitro studies based on a TCML design. Two more in vivo studies could be added after the brand name search. Altogether, 15 in vivo studies and 6 in vitro studies were included in our analysis.
Conclusion: Because of the low number of studies available, the clinical evidence of self-adhesive luting agents cannot be assessed in a sufficient manner.

Clinically successful marginal sealing can be achieved by using dentine and enamel adhesive systems. The three-step system consisting of etching, priming, and bonding is still the gold standard for the marginal adaption of tooth substance and restorative materials. Many literature reports have described the clinical success of such adhesive systems.[1-3] However, the adhesive luting procedure is complex and technically sensitive. Dentists are keen to align the adhesive luting procedure to that used for conventional luting agents. Self-adhesive resin cements may combine the advantages of both adhesive and conventional luting agents.

The first cement combining the advantages of adhesive and conventional luting agents was introduced into the dental market in 2002. Other products have followed over the past few years. By now, dentists may choose among at least ten different self-adhesive cements. Although single chemical or physical properties have been analyzed in simple in vitro studies,[4] sophisticated clinical investigations of these new types of cements are still rare. Because of their increasing popularity, we reviewed the literature on self-adhesive cements to investigate their clinical performance. We hypothesized that after 10 years, a sufficient number of clinical studies should exist to assess whether self-adhesive luting agents represent a good treatment option in comparison to traditional multistep adhesive luting systems.

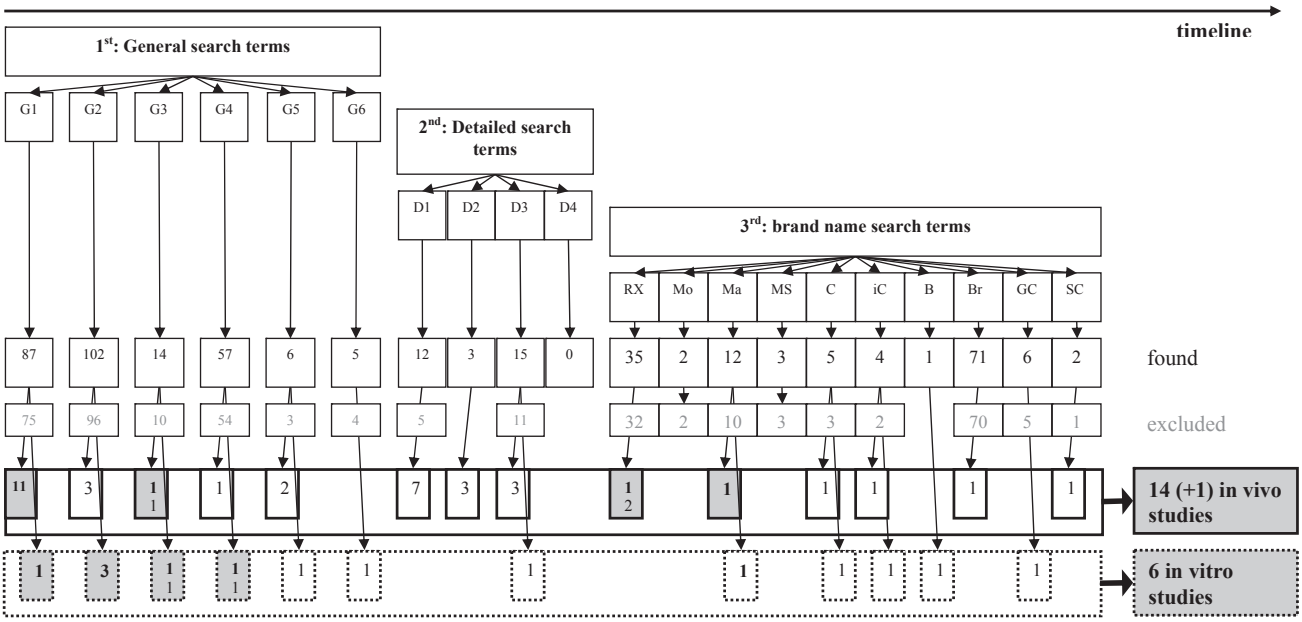
Materials and methods

We conducted a literature search using the search terms stated below by means of the digital archive PubMed during a 1-week period in March 2013. Afterwards, we manually searched the obtained lists for relevant clinical studies by reading each article to analyze its study design. Because of the low number of relevant articles, we decided to broaden the search by including in vitro studies based on a thermal cycling and mechanical loading (TCML) design. These lists were searched once again for in vitro studies, in which restorations were treated within a sophisticated chewing simulation process.[5,6] These studies were identified by reading the abstracts and searching for indications of a TCML design. If no indication was found in the abstract, we scanned the "Materials and Methods" section. Consequently, we excluded every study without thermal cycling and simultaneous manual loading procedures. Moreover, we also excluded all articles on self-adhesive resin cements in combination with post systems. We found that RelyX Unicem (3M ESPE Neuss, Germany) was the only self-adhesive resin cement investigated in more than one article. To confirm this result, we explicitly searched for the brand names, using the search term "clinical study AND 'brand name'." All search terms used are listed in Table 1, and Figure 1 shows the sequences of the structured search.

Table 1 Search terms

Abbreviation	General search	Abbreviation	Brand name search: clinical study +
G1	"Self-adhesive resin cement"	RX	"RelyX Unicem"
G2	"Self-adhesive resin cements"	Mo	"MonoCem"
G3	"Self-adhesive universal resin cement"	Ma	"MaxCem"
G4	"Self-adhesive universal resin cements"	MS	"Multilink Sprint"
G5	"Self-adhesive luting agent"	C	"Clearfil SA"
G6	"Self-adhesive luting agents"	iC	"iCEM self adhesive"
	Detailed search	B	"Bifix SE"
D1	Clinical study "self-adhesive resin cement"	Br	"Breeze"
D2	Clinical outcomes "self-adhesive resin cement"	GC	"G-Cem"
D3	Clinical study "self-adhesive resin cements"	SC	"SmartCem 2"
D4	Clinical outcomes "self-adhesive resin cements"		

List of all search terms used in this review. The search was structured as follows: first, general search; second, detailed search; third, brand name search.



1. The abbreviations in the top part of this flip chart are explained in Table 1.
2. The numbers in the grey boxes show newly included studies.
3. If a grey box contains two numbers, the bold typed upper number shows a new article that was added to that review.
4. The numbers in the white boxes (only in the last two lines) show articles that had been previously found with another search term.
5. One article was found by scanning the references of the other articles.

Figure 1 Flip chart of study.

Our search in PubMed yielded 87 articles on "self-adhesive resin cement." Eleven of them were clinical studies that were included in our analysis (cf., Data and Sources). Two of these eleven articles showed intermediate results.[7-10] Additionally, we found one in vitro study based on a TCML design (Table 2). The next general search term was the plural form of the first search term: "self-adhesive resin cements." Six of the 102 papers found referred to in vivo studies, but three of these six articles had already been found within the first search.[11,12] However, three more complex in vitro studies were obtained.[13-15] The search with the terms "self-adhesive universal resin cement" and "self-adhesive universal resin cements" yielded two further in vitro studies.[16,17] No further studies that would have been of interest for this review could be found using the above search terms.

Our attempt to find more relevant studies with other search terms failed. No articles were found using the search terms "self-adhesive luting agent," "self-adhesive luting agents," "clinical study 'self-adhesive resin cement'," "clinical outcomes 'self-adhesive resin cement'," "clinical study 'self-adhesive resin cements'," and "clinical outcomes 'self-adhesive resin cements'" (Table 3).

The last search using the terms "clinical study AND '*brand name of the cement*'" yielded two further articles (Table 4)

Table 2 General search

	Total number of studies	In vivo studies	In vitro studies with TCML	Excluded studies
"Self-adhesive resin cement"	87	11	1	75
"Self-adhesive resin cements"	102	3	3	96
"Self-adhesive universal resin cement"	14	2	2	10
"Self-adhesive universal resin cements"	57	1	2	54
"Self-adhesive luting agent"	6	2	1	3
"Self-adhesive luting agents"	5	0	1	4
Number of relevant articles	18	12(2)*	6	–

It should be noted that several articles were found in more than one search. Therefore, the total number of included manuscripts is less than the overall amount of articles found with each search term. The term 'relevant' implies all clinical articles and TCML in vitro studies.
*The number in parentheses refers to those articles that show intermediate results of clinical studies.

Table 3 Detailed search

	Total number of studies	In vivo studies	In vitro studies with TCML	Excluded studies
Clinical study "self-adhesive resin cement"	12	7	0	5
Clinical outcomes "self-adhesive resin cement"	3	3	0	0
Clinical study "self-adhesive resin cements"	15	3	1	11
Clinical outcomes "self-adhesive resin cements"	0	0	0	0
Newly found articles added	0	0	0	–

List of all detailed search terms used. The last line shows that no new articles could be included.

Table 4 Brand name search

	Total number of studies	In vivo studies	In vitro studies with TCML	Excluded studies
Clinical study "RelyX Unicem"	35	3	0	32
Clinical study "MonoCem"	2	0	0	2
Clinical study "MaxCem"	12	1	1	10
Clinical study "Multilink Sprint"	3	0	0	3
Clinical study "Clearfil SA"	5	0	1	3
Clinical study "iCEM self adhesive"	4	1	1	2
Clinical study "Bifix SE"	1	0	1	0
Clinical study "Breeze"	71	1	0	70
Clinical study "G-Cem"	6	0	1	5
Clinical study "SmartCem 2"	2	1	0	1
Newly found articles added	0	1(1)*	0	–

List of all brand name search terms used. The last line shows that two more studies were included. One of them is again a paper showing intermediate results of a clinical study.
*The number in parentheses refers to those articles that show intermediate results of clinical studies.
The high number of articles for the column "Breeze" is attributable to the surname "Breeze" in English language regions.

that included a 1-year investigation by Schenke et al[18] and a 3-year clinical evaluation by Atali et al.[19] We also checked the references of every included article for any hints for clinical studies on this topic. Overall, 21 articles could be listed (Fig 1). Six were in vitro studies based on a TCML design and the other 15 were clinical studies, of which three showed primary results.[7,8,18]

Results

In vivo studies

Only 15 clinical studies on self-adhesive resin cements (Table 5) could be found. Three showed primary results: Schenke et al as well as Taschner et al[8,9] published 1-year[18] and 2-year results.[11] Peumans et al primarily published their results after 2 years[7] and secondarily after 4 years.[10]

Full crowns

Behr et al[20] published the results of the clinical performance of the self-adhesive resin cement RelyX Unicem in comparison to zinc oxide phosphate cement. After an observation time of 3.16 years, none of the 49 cemented metal-based fixed partial dentures (FPDs) had been lost, so that recementation was not necessary. In the self-adhesive composite group, one patient required endodontic treatment after 2.9 years. In comparison to

Table 5 Clinical studies on self-adhesive resin cements

Author	Year	Patients(*n*)	Specimens	Products	Outcome
Taschner et al[8]	2009	30	83 IPS Empress restorations	RelyX Unicem, Syntac Classic with Variolink II	Variolink II (with Syntac) showed significantly better results regarding color match and integrity inlay
Taschner et al[9]	2012	30	83 IPS Empress restorations	RelyX Unicem, Syntac Classic with Variolink II	RelyX with clinically acceptable results after 2 years, even if tooth and marginal integrity were lower than with conventional adhesive luting agents
Behr et al[20]	2009	49	49 alloy-based FPDs	Zinc phosphate cement, RelyX Unicem Aplicap	No significant difference between zinc oxide phosphate cement and RelyX Unicem
Peumans et al[7]	2010	31	62 IPS Empress II inlays or onlays	RelyX Unicem	Selective enamel etching before luting did not significantly influence marginal integrity, inlay integrity, tooth integrity, sensitivity, or complications of the restored teeth after 24 months
Peumans et al[10]	2012	31	62 IPS Empress II inlays or onlays	RelyX Unicem	Also after 48 months, selective enamel etching did not improve clinical performance, although all restorations showed clinically acceptable marginal deterioration
Saad et al[12]	2010	20	50 alloy-based FPDs	RelyX Unicem, Breeze self-adhesive resin cement, RelyX ARC, RelyX Unicem	Self-adhesive resin cements had less post-cementation sensitivity than resin cement in combination with the total-etch technique
Piwowarczyk et al[21]	2011	20	40 alloy-based FPDs	Zinc phosphate cement, RelyX Unicem	RelyX Unicem had lower sulcus fluid flow rates than zinc phosphate cement
Schenke et al[18]	2010	29	68 Cerec Vita Mark II PCCs	RelyX Unicem	After 1 year, adhesive luting with or without enamel etching could be recommended; no significant differences between the RXU and RXU+E group could be found
Schenke et al[11]	2012	29	68 Cerec Vita Mark II PCCs	RelyX Unicem	2-year results indicated a tendency for better results in case of selective enamel etching before the insertion of ceramic PCCs
Azevedo et al[24]	2012	25	42 Filtek Supreme XT (3M ESPE) inlays or onlays	RelyX Unicem	All composite inlays or onlays were clinically acceptable after 1 year of clinical service, irrespective of enamel etching
Blatz et al[31]	2012	70	88 cast	iCem, GC Fuji PLUS(GC America, Alsip, IL USA)	7 days after cementation, iCem showed significantly lower postoperative sensitivity than GC Fuji PLUS
Shetty et al[32]	2012	50	50 full crowns	SmartCem 2, GC luting cement (GC America, Alsip, IL USA)	7 days after cementation, SmartCem 2 showed significantly lower postoperative sensitivity than GC Luting cement
Perry et al[25]	2012	15	16 Lava zirconia FPDs	RelyX Unicem	After 2 years, all restorations were in situ and clinically acceptable
De Souza Costa[33]	2006	?	34 composite inlays	RelyX Unicem, Variolink II + Total Etch + Excite	Variolink II in combination with Excite (+Total Etch) affects the pulp-dentin complex more negatively than RelyX Unicem
Atali et al[19]	2011	20	20 IPS Empress onlays	MaxCem, Clearfil Esthetic Cement + DC Bond Kit	For the luting of ceramic onlays, no difference between MaxCem and Clearfil Esthetic Cement could be detected

zinc phosphate cement, the self-adhesive resin cement RelyX Unicem showed a comparable clinical performance. The only differences between the two cements seemed to be plaque accumulation and the gingival bleeding score at baseline, which was maintained throughout the study. Plaque score values were higher for RelyX Unicem at baseline and at the end of the study. In contrast, Piwowarczyk et al[21] found that restorations cemented with the self-adhesive resin cement RelyX Unicem were associated with less inflammation in the periodontal pockets and on the gingiva, which was probably due to good cross-linking and the resulting lower solubility of this type of cement in water.

Both abovementioned studies reported one case of vitality loss of an abutment tooth with a deep carious lesion. One abutment was luted with RelyX Unicem,[20] the other with Harvard Cement.[21] In their clinical study, Saad et al[12] reported that the self-adhesive resin cements "RelyX Unicem" and "Breeze" (Synca, Quebec, Canada) showed significantly less postcementation sensitivity than resin cements that involve the use of a total etch technique (RelyX ARC) in a 12-week timeframe. Two abutments fixed with RelyX ARC required endodontic therapy.

Partial crowns

In contrast to full crowns, bonding to enamel is investigated in partial crowns because of the preparation margin within the enamel. Because of the weaker acidity present in self-adhesive resin cements, the structure of enamel is assumed to be inadequately demineralized for sufficient etching patterns.[22]

Schenke et al[11,18] and Peumans et al[7,10] used a similar study design. Within the framework of prospective randomized controlled clinical studies, both investigated the success of RelyX Unicem by means of Empress 2 inlays or onlays. In each study, two groups were prepared: in the first group, the inlays or onlays were luted with RelyX Unicem without any separate etching of the enamel (control group). In the second group, the luting procedure included etching the enamel with phosphoric acid (experimental group). Both studies showed a success rate of 96.6% after 2 years. Schenke et al had a failure rate of 5.1% for the RelyX group and 1.7% for the RelyX + enamel etch group. Similarly, Peumans et al's failure rate was 3.4% (0% in the etch group, 6.7% in the nonetch group). Although insignificant, these values tended to be lower when the enamel was etched separately. After 4 years, the failure rate of Peumans' investigation was 5% (3% in the etch group, 7% in the nonetch group). This result did not significantly differ between the two groups. Furthermore, marginal discoloration was also found to be higher in the nonetch group,[11] probably because the fillers were cropped out from the resin matrix during tooth brushing.[23] Azevedo et al[24] also stated that enamel etching had no clinical relevance on the marginal quality of indirect composite resin restorations. Overall, the advantage of selective enamel etching upon marginal adaption in the clinical situation could not be confirmed by either of these two studies, although it was advocated for in vitro studies; however, it should be mentioned that, in these two studies,[7,11] RelyX was bonded to enamel surfaces only. Taschner et al reported 29 of 62 restorations with 0.5 mm or less enamel left at the cervical margin.[8] In their 2-year clinical study, these authors[9] showed an acceptable performance of the self-adhesive resin cement RelyX Unicem;[25] however, tooth integrity and marginal integrity were lower than for conventional multistep systems. In contrast, Atali et al[19] found no difference between the self-adhesive cement MaxCem (KERR, Charlotte, NC USA) and the multistep system Clearfil Esthetic Cement + DC Bond Kit in 20 crowns (n = 10 each) that were made and observed for 3 years.

In vitro studies

The six in vitro research papers found (Table 6) investigated the tensile strength and marginal adaption of self-adhesive resin cements, particularly that of RelyX Unicem®. These investigations were included in this review because of their representative simulation of a 5-year period of oral stress influencing the marginal integrity of indirect restorations.[6] Since the parameters used (50 N, 1.2×10^6 cycles mechanical load, 6000 cycles of thermocycling) caused similar failure patterns for Variolink II compared to clinical data, results of in vitro studies based on a TCML design may be assumed to be similar to those of clinical studies.[26]

Full crowns

Behr et al[16] showed that the self-adhesive resin cement RelyX Unicem can provide marginal adaption in dentine without any pretreatment. In this study, 32 full crowns made of Empress 2 ceramic were luted onto extracted teeth with RelyX (with and without any pretreatment), Variolink II, + Syntac Classic (4 steps), or Dyract Cem (Plus, Dentsply, York, PA USA)(3 steps). The scanning electron microscopy analysis did not show any significant difference between the cements used. All results showed a perfect margin of about 90%. The only mismatch was found in the dye penetration test. The results showed values of almost 100% penetration for Syntac and Dyract Cem in contrast to the RelyX groups (between 10% and 25%), which was mainly caused by the inhibited setting reaction. Stawarczyk et al[13] tested the impact of the primer Gluma Desensitizer (Heraeus, Hanau, Germany) on the tensile strength of zirconia crowns bonded to dentine. The investigators found that—after TCML—the self-adhesive cements RelyX Unicem and G-Cem (GC America, Alsip, IL USA) combined with Gluma Desensitizer had significantly higher tensile strength than Panavia 21.

In contrast to these two studies, Kassem et al[27] showed that crowns made of Vita Mark II ceramic had a higher failure rate after the chewing simulation when fixed with the self-adhesive resin cement RelyX Unicem than crowns fixed with Panavia F2.0. Moreover, crowns fixed with this self-adhesive cement showed a higher rate of microleakage than crowns fixed with Panavia F2.0.

Partial crowns

The lowest rate of microleakage in the investigation by Schenke et al[17] was found for the self-adhesive luting material RelyX

Table 6 Complex in vitro studies on self-adhesive resin cements

Author	Year	Specimen (*n*)	Products	Outcome
Behr et al[16]	2004	32 Empress II	Variolink II, Dyract Cem Plus, RelyX Unicem	Self-adhesive resin cements without any pretreatment provided marginal adaptation at dentine similar to established luting agents
Behr et al[14]	2009	32 Empress II	MaxCem, Multilink Sprint, RelyX Unicem Clicker, Panavia F2.0	Self-adhesive resin cements did not reach the levels of well-tried multistep adhesive systems
Aschenbrenner et al[15]	2012	32 Empress II	Clearfil SA, iCEM, Bifix SE, seT	The self-adhesive resin cements seemed to successfully bond to dentine- and enamel-restricted cavities
Schenke et al[17]	2008	84 Vita Mark II	Variolink II, Panavia, RelyX Unicem	Resin-coating technique improved the marginal integrity at the dentine or composite interface compared to the conventional luting technique
Kassem et al[27]	2012	32 Vita Mark II, Paradigm-MZ100 (resin)	Panavia F 2.0, RelyX Unicem	Microleakage scores of ceramic crowns cemented with Panavia F2.0 were significantly lower than those of the other three groups
Stawarczyk et al[13]	2012	144 Zirconia	Panavia21, RelyX Unicem, G-Cem, Gluma Desensitizer	Self-adhesive resin cements with Gluma Desensitizer showed better long-term results than conventional resin cements

Unicem. The resin-coating technique improved the marginal integrity at the dentine and composite interface compared to the conventional luting technique; however, this resin-coating technique neutralizes the advantage of self-adhesive resin cements to save time during handling: Before the cementation of the restoration, a thin layer of a dental composite was applied onto the dentine surface by means of a bonding system. Although inlays were tested, only the influence of the materials at the dentine margin was examined. For this reason, the results of this article could be compared with those of the abovementioned studies with full crowns.[13,16,27]

Behr et al[14] investigated the clinical performance of inlays luted with RelyX Unicem, Panavia F2.0, MaxCem, and Multilink Sprint (Ivoclar Vivadent, Schaan, Liechtenstein). The authors manufactured 32 Empress II (Ivoclar Vivadent, Schaan, Liechtenstein) all-ceramic MOD-inlays luted with the aforementioned four self-adhesive composite cements that had undergone a simulated 5-year period of oral stress. The weak point of RelyX Unicem was its poorer adhesion to enamel than the well-tried control Panavia F2.0. This result agreed with other literature reports describing the better adhesion of RelyX Unicem to dentine than to enamel surfaces.[22,28] Although the cement MaxCem seemed to work better on enamel, the dye penetration tests showed poorer—although insignificant—results on dentine than for RelyX Unicem. Multilink Sprint showed the worst performance of all evaluated cements on all surfaces and interfaces. In summary, that study showed that not all self-adhesive resin cements reach the same level of performance as the well-tried multistep adhesive systems.

Aschenbrenner et al[15] compared the marginal adaption of all-ceramic MOD-inlays (Empress II) luted onto human molars with four self-adhesive composite cements. For Clearfil SA (Kuraray, Hattersheim, Germany), iCEM, Bifix SE (VOCO, Cuxhaven, Germany), and seT, the dye penetration test showed very low rates of dye entry into enamel compared to multistep systems, e.g., Panavia F 2.0. The marginal fit appeared to be better in enamel than in dentine. These results may be explained by an enhanced chemical interaction with enamel, presumably due to variations in the pH value of the new cements. Some authors have postulated that the lower pH values of self-adhesive cements as well as additional selective etching of the enamel margins may enhance the adhesion to enamel; however, the data show that improved bonding to enamel does not implicate comparable adhesion to dentine. Finding the right balance to achieve similar bonding to dentine and enamel still seems to be difficult.

Discussion

Ten years after the market launch of the first self-adhesive resin cement, this study analyzes previous clinical studies to find out whether self-adhesive luting agents represent a treatment option as reliable as traditional multistep adhesive luting systems and conventional cements. Because the search for relevant clinical studies only yielded 14 clinical investigations, we broadened our search and included in vitro studies investigating the luting agent under conditions similar to those in clinical practice. Therefore, such studies had to include thermocycling and mechanical loading methods.[5,6] This

approach allowed us to list more self-adhesive resin cements: MonoCem (Shofu, San Marcos, CA USA), Multilink Sprint, Clearfil SA, Bifix SE, and G-Cem. Table 4 shows that RelyX Unicem, MaxCem, SmartCem 2 (Dentsply, York, PA USA), iCem (Heraeus, Hanau, Germany) self-adhesive, and Breeze are the only self-adhesive cements that have ever been tested in an in vivo study. The self-adhesive resin cements Breeze, SmartCem 2, iCem self-adhesive, and MaxCem were only tested in one study each, whereas RelyX Unicem was assessed in 12 in vivo investigations. So far, we have not found any clinical studies on MonoCem, Multilink Sprint, Clearfil SA, Bifix SE, or G-Cem. RelyX Unicem remains the only self-adhesive resin cement with clinical references.

Conventional cementation versus self-adhesive cementation

This review lists three clinical studies that tested RelyX Unicem in comparison to conventional cementations. In the studies by Behr et al[20] and Piwowarczyk et al,[21] none of the altogether 89 crowns were lost at the end of the study. These results indicate that self-adhesive resin cements may be as suitable as the well-tested zinc oxide phosphate cement.[29] Both studies listed one vitality loss each, one in the zinc oxide phosphate group[21] and the other in the RelyX Unicem group.[20] Based on these results, vitality loss cannot be ascribed to the luting agent used. As the authors stated, vitality loss was caused by the deep carious defects of the respective teeth.

Multistep systems versus one-step systems

Inlays, onlays, and partial crowns made of glass ceramic need to be luted adhesively. For this reason, resin cements should be used in combination with adhesive systems in such cases; however, this method is technically very sensitive. To make this procedure much easier, self-adhesive resin cements could be used alternatively. The clinical performance of these cements was compared to the standard luting materials Variolink II and, as gold standard, Panavia F 2.0 in five in vitro investigations and three in vivo investigations.[7-11,13,14,16-18,27] Because the self-adhesive luting agents Multilink Sprint[14] and G-Cem[13] were only used once, a well-founded statement on their performance was not possible. The same applied to MaxCem, even if it was investigated twice.[14,19] In contrast, RelyX Unicem was tested in 5 in vitro and in 12 in vivo investigations.

Behr et al, Stawarczyk et al, and Schenke et al[14,16,17] could show comparable results for RelyX Unicem and Variolink II or Panavia F 2.0; however, Stawarczyk et al and Schenke et al only tested the adhesion to dentine, whereas Behr et al[14] investigated the adhesion to both dentine and enamel. Behr et al found significantly lower values of marginal adaption for RelyX Unicem luted to enamel than for Panavia. For dentine, the results for RelyX Unicem and Panavia F2.0 were comparable. Taschner et al[8,9] confirmed these in vitro results in their clinical investigation. Because of the large size of the dentine surfaces prepared for inlays and onlays, such restorations are clinically acceptable, independent of the material used for luting, that is, Syntac Classic and Variolink II or RelyX Unicem.

This observation was separately explored by Schenke et al[11,18] and Peumans et al.[7,10] These authors did not find any significant difference between the enamel etch groups and the enamel nonetch groups of the partial crowns after 4 years of wear. Schenke et al described a tendency for better results in case of selective enamel etching before the insertion of partial ceramic crowns. The investigations by Stawarczyk et al[13] and Schenke et al[17] have to be critically discussed. In Stawarczyk et al's study, a layer of the dentine desensitizer was placed between the dentine and the self-adhesive luting agent. Schenke et al[17] applied a thin layer of composite before luting the restoration (resin coating technique). These steps do not allow any statements about the behavior of self-adhesive resin cements on dental surfaces.

Plaque score and bleeding index

We listed two studies[20,21] on plaque scores and bleeding indices. In contrast to Behr et al,[20] Piwowarczyk et al[21] used a split-mouth study design. Although the studies were similar, they yielded opposite results: Behr et al found higher plaque scores, bleeding scores, and attachment loss for RelyX Unicem than for the inorganic zinc phosphate cement; however, these results were not statistically significant. Behr et al explained these results as follows: Bacteria colonize resin surfaces more frequently than surfaces of inorganic substrates. Furthermore, any excess of RelyX Unicem in the sulcus cannot be removed as easily as zinc phosphate cement. In contrast, Piwowarczyk argued that the lower sulcus fluid flow rates for RelyX Unicem found in his study were due to the lower solubility of RelyX Unicem in water. Thus, RelyX Unicem results in less inflammation in the periodontal pockets than zinc oxide phosphate cement. A clear statement about the influence of self-adhesive resin cements on the gingiva and the alveolar bone cannot be made. Accurate and complete removal of excess cementation is essential to reduce the risk of inflammation in the sulcus.[30]

Postoperative sensitivity

Six of the 14 in vivo studies found dealt with this issue.[12,21,24,31-33] All authors agreed that self-adhesive resin cements showed less postoperative sensitivity than the classic total-etch technique or conventional cements, such as glass ionomer or zinc phosphate cements. The main problem of the total-etch technique is the acid etching of the dentinal surface, particularly when systems are used incorrectly. Over-etching or over-drying, for example, trigger the removal of the smear layer and create a passage by which bacteria may penetrate the pulp. Moreover, the monomers of the bonding system can also penetrate into the pulp.[12] De Souza Costa et al[33] verified this finding by examining extracted sound human teeth that had been treated in vivo with composite inlays and had either been fixed with RelyX Unicem or with Variolink II plus Excite. Thus, a persistent chronic inflammatory response and tissue disorganization for the total-etch technique could be proven. In contrast, use of RelyX Unicem only triggered an inflammatory reaction during the 7-day period because of the low pH setting reaction. RelyX Unicem alters the smear layer, thus avoiding resin tags. In other words, the chemical reaction of self-adhesive

resin cements is superficial without further hydrolysis and release of components to diffuse across dentinal tubules. Even compared to glass ionomer cements, self-adhesive resin cements showed significantly lower postoperative sensitivity.[31,32] The authors explained this difference with the mild citric acid of the conditioner used in combination with glass ionomer cement. Only Piwowarczyk et al[21] did not find any difference between RelyX Unicem and a zinc phosphate cement after an observation period of 1.8 years. In principle, self-adhesive resin cements had less influence on the pulp than other luting systems, particularly compared to total-etch systems. The limiting factor of these studies is the difference in preparation guidelines and the subjective assessment of the study participants. Blatz et al,[31] for example, included both male and female patients with an age range from 24 to 65 years. In contrast, Saad et al[12] only included female participants aged between 30 and 40 years. Thus, the perception of pain tends to be more comparable.

Conclusions

Because of the low number of studies available, the clinical evidence of self-adhesive luting agents cannot be assessed in a sufficient manner.

References

1. Beier US, Kapferer I, Dumfahrt H: Clinical long-term evaluation and failure characteristics of 1,335 all-ceramic restorations. Int J Prosthodont 2012;25:70-78
2. van Dijken JW, Hasselrot L: A prospective 15-year evaluation of extensive dentin-enamel-bonded pressed ceramic coverages. Dent Mater 2010;26:929-939
3. Krämer N, Reinelt C, Richter G, et al: Four year clinical performance and marginal analysis of pressed glass ceramic inlays luted with ormocer restorative vs. conventional luting composite. J Dent 2009;37:813-819
4. Radovic I, Monticelli F, Goracci C, et al: Self-adhesive resin cements: a literature review. J Adhes Dent 2008;10:251-258
5. Behr M, Weiser F, Meier M, et al: Influence of water sorption of the underlying abutment on fracture resistance of zirconia copings. Acta Odontol Scand 2011;69:170-175
6. Rosentritt M, Behr M, Gebhard R, et al: Influence of stress simulation parameters on the fracture strength of all-ceramic fixed-partial dentures. Dent Mater 2006;22:176-182
7. Peumans M, De Munck J, Van Landuyt K, et al: Two-year clinical evaluation of a self-adhesive luting agent for ceramic inlays. J Adhes Dent 2010;12:151-161
8. Taschner M, Frankenberger R, García-Godoy F, et al: IPS Empress inlays luted with a self-adhesive resin cement after 1 year. Am J Dent 2009;22:55-59
9. Taschner M, Krämer N, Lohbauer U, et al: Leucite-reinforced glass ceramic inlays luted with self-adhesive resin cement: a 2-year in vivo study. Dent Mater 2012;28:535-540
10. Peumans M, Voet M, De Munck J, et al: Four-year clinical evaluation of a self-adhesive luting agent for ceramic inlays. Clin Oral Investig 2013;17:739-750
11. Schenke F, Federlin M, Hiller KA, et al: Controlled, prospective, randomized, clinical evaluation of partial ceramic crowns inserted with RelyX Unicem with or without selective enamel etching. Results after 2 years. Clin Oral Investig 2012;16:451-461
12. Saad Del-D, Atta O, El-Mowafy O: The postoperative sensitivity of fixed partial dentures cemented with self-adhesive resin cements: a clinical study. J Am Dent Assoc 2010;141:1459-1466
13. Stawarczyk B, Hartmann L, Hartmann R, et al: Impact of Gluma Desensitizer on the tensile strength of zirconia crowns bonded to dentin: an in vitro study. Clin Oral Investig 2012;16:201-213
14. Behr M, Hansmann M, Rosentritt M, et al: Marginal adaptation of three self-adhesive resin cements vs. a well-tried adhesive luting agent. Clin Oral Investig 2009;13:459-464
15. Aschenbrenner CM, Lang R, Handel G, et al: Analysis of marginal adaptation and sealing to enamel and dentin of four self-adhesive resin cements. Clin Oral Investig 2012;16:191-200
16. Behr M, Rosentritt M, Regnet T, et al: Marginal adaptation in dentin of a self-adhesive universal resin cement compared with well-tried systems. Dent Mater 2004;20:191-197
17. Schenke F, Hiller KA, Schmalz G, et al: Marginal integrity of partial ceramic crowns within dentin with different luting techniques and materials. Oper Dent 2008;33:516-525
18. Schenke F, Federlin M, Hiller KA, et al: Controlled, prospective, randomized, clinical evaluation of partial ceramic crowns inserted with RelyX Unicem with or without selective enamel etching. 1-year results. Am J Dent 2010;23:240-246
19. Atali PY, Cakmakcioglu O, Topbasi B, et al: IPS Empress onlays luted with two dual-cured resin cements for endodontically treated teeth: a 3-year clinical evaluation. Int J Prosthodont 2011;24:40-42
20. Behr M, Rosentritt M, Wimmer J, et al: Self-adhesive resin cement versus zinc phosphate luting material: a prospective clinical study begun 2003. Dent Mater 2009;25:601-604
21. Piwowarczyk A, Schick K, Lauer HC: Metal-ceramic crowns cemented with two luting agents: short-term results of a prospective clinical study. Clin Oral Investig 2012;16: 917-922
22. De Munck J, Vargas M, Van Landuyt K, et al: Bonding of an auto-adhesive luting material to enamel and dentin. Dent Mater 2004;20:963-971
23. Kashiwada T, Morita M, Kato S: Abrasion behavior of an experimental resin modified glass ionomer cement. J Dent Res 2006;84(special issue A):533
24. Azevedo CG, De Goes MF, Ambrosano GM, et al: 1-Year clinical study of indirect resin composite restorations luted with a self-adhesive resin cement: effect of enamel etching. Braz Dent J 2012;23:97-103
25. Perry RD, Ferreira S, Magnuson B: Two-year evaluation indicates zirconia bridges acceptable alternative to PFMs. Compend Contin Educ Dent 2012;33:E1-E5
26. Rosentritt M, Siavikis G, Behr M, et al: Approach for valuating the significance of laboratory simulation. J Dent 2008;36:1048-1053
27. Kassem AS, Atta O, El-Mowafy O: Fatigue resistance and microleakage of CAD/CAM ceramic and composite molar crowns. J Prosthodont 2012;21:28-32
28. Hikita K, Van Meerbeek B, De Munck J, et al: Bonding effectiveness of adhesive luting agents to enamel and dentin. Dent Mater 2007;23:71-80
29. Hill EE, Lott J: A clinically focused discussion of luting materials. Aust Dent J 2011;56:67-76
30. Freilich MA, Niekrash CE, Katz RV, et al: The effects of resin-bonded and conventional fixed partial dentures on the periodontium: restoration type evaluated. J Am Dent Assoc 1990;121:265-269

31. Blatz MB, Mante FK, Saleh N, et al: Postoperative tooth sensitivity with a new self-adhesive resin cement-a randomized clinical trial. Clin Oral Investig 2013;17:793-798
32. Shetty RM, Bhat S, Mehta D, et al: Comparative analysis of postcementation hypersensitivity with glass ionomer cement and a resin cement: an in vivo study. J Contemp Dent Pract 2012;13:327-331
33. de Souza Costa CA, Hebling J, Randall RC: Human pulp response to resin cements used to bond inlay restorations. Dent Mater 2006;22:954-962
34. Manhart J, Chen H, Hamm G, et al: Buonocore Memorial Lecture. Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition. Oper Dent 2004;29:481-508