Survival Rates of Teeth, Implants, and Double Crown–Retained Removable Dental Prostheses: A Systematic Literature Review

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> **Purpose:** The aim of this systematic literature review was to investigate the survival rates of teeth, implants, and double crown-retained removable dental prostheses (RDPs). Materials and Methods: A systematic review of the literature published from January 1973 through May 2010 was conducted using electronic databases and hand-searching to assess the clinical outcomes of teeth, implants, and double crown-retained RDPs. **Results:** This review yielded 512 articles, which were narrowed down to 11. The included studies demonstrated tooth survival rates between 60.6% and 95.3% after an observation period of 4 to 10 years. The survival rates of RDPs supported by teeth ranged between 90.0% and 95.1% after 4 and 5.3 years, respectively. The survival rates of implants supporting prostheses in the mandible were between 97% and 100% after an observation period between 3 and 10.4 years. The survival rates of implant-retained RDPs in the mandible ranged between 95% and 100% after 9 and 10.4 years. Teeth and implants supporting prostheses in the maxilla, as well as the RDPs themselves, demonstrated a survival rate of 100% after 3.2 years. Conclusion: The current literature does not provide sufficient information regarding the long-term outcome of double crown-retained RDPs. Further studies based on a higher level of evidence are needed to validate the outcomes of this treatment modality. Int J Prosthodont 2011;24:109–117.

Tooth loss is associated with limitations regarding esthetics, function, comfort, and quality of life and may lead to nutrition and weight problems, emotional disturbances, and neuromuscular alterations. Consequently, the remaining teeth may suffer overload; approximal, mesial, or distal drift; elongation; or abrasion.¹

Partially edentulous arches can be restored with tooth-, implant-, or tooth and implant-supported double crown-retained removable dental prostheses (RDPs). They guarantee easy accessibility for dental hygiene and the possibility of extraoral repair.²⁻⁶ Disadvantages include loss of retention, food impaction, and caries.²⁻⁸

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Double crown-retained RDPs are mainly used in Germany, Sweden, and Japan.^{5,9} This type of prosthetic treatment is characterized by a hybrid form of fixed and removable dental prostheses: An inner crown or primary crown is permanently cemented or fixed to the abutment tooth or implant, and a congruent outer crown or secondary crown is rigidly anchored in the detachable prosthesis.¹⁰ Depending on the retention mechanism, double crowns can be subdivided into telescopic crowns, conical crowns, and double crowns with additional modifications.¹¹

The telescopic crown (composed of a high precious metal alloy) was first introduced by Böttger in 1961.¹² It has a parallel design and uses the friction of the opposing surfaces of the inner and outer crowns for retention. Böttger suggested using retention pins to increase retention if a non-precious metal alloy was used. Telescopic crowns can be either rigid or nonrigid. Rigid telescopic crowns have a defined end position, meaning that these crowns do not allow further vertical movement under load. Nonrigid telescopic crowns, have no defined apical end position, meaning that they allow a certain amount of vertical movement under load. It was thought that nonrigid crowns better distribute forces to the mucosal rest areas than rigid crowns.¹³

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Conical crowns were introduced by Körber in 1968.¹⁴ They have a tapered design, which creates friction at the end position. A taper of 6 degrees is recommended to achieve a retention force between 5 and 10 N when using high precious alloys.¹¹

The Marburg double crown system, first described by Lehmann and Gente in 1988,¹⁵ uses additional prefabricated elements (TC-Snap System, Si-tec) to improve the retention of telescopic crowns.

Each of the three different types of double crown systems can be employed to support either a removable dental prosthesis or an overdenture prosthesis.¹⁶ Indications for using double crown–retained RDPs are arches with few remaining teeth, implants, or both.^{13,17,18} Double crowns are contraindicated when the clinical crown of the abutment tooth is too short (< 3 mm) or the patient has a low level of compliance, shows insufficient oral hygiene, or finds a removable prosthesis unacceptable.¹⁹

The purpose of this review was to investigate the survival rates of teeth, implants, and double crown-retained RDPs.

Materials and Methods

Search Strategy and Study Selection

A PubMed (Medline) search was conducted for articles published in the dental literature from January 1973 to May 2010 using the following search terms in simple or multiple conjunctions: "double crowns," "RDPs," "teeth," and "implants." The bibliographies of all full-text articles and related reviews selected from the electronic search were also screened. Furthermore, manual searching was applied to the following journals from 1989 to May 2010: Clinical Oral Investigations, Deutsche Zahnärztliche Zeitschrift, European Journal of Prosthodontics and Restorative Dentistry, International Journal of Periodontics & Restorative Dentistry, International Journal of Prosthodontics, Journal of Prosthetic Dentistry, and Journal of Prosthodontics. Since double crownretained RDPs were introduced in German-speaking countries and are mainly fabricated in such countries, the vast majority of studies identified were in German. For this reason, the keywords used for the literature search were translated into German as well.

Studies were screened based on the following inclusion criteria: clinical studies, mean follow-up time of 3 years, randomized controlled trials (RCTs) and prospective and retrospective studies, cumulative survival rates given, papers reporting details on the attachment system, and publications available in German or English. The exclusion criteria consisted of: case reports, in vitro studies, publications comparing different attachment systems but not presenting separate survival rates, patient records only, duplicate studies on the same patient population, studies reporting on maxillofacial prostheses, no data on number of patients, no survival rates of teeth and implants, and publications presenting success rates only (Table 1).

Titles and abstracts were initially screened independently by two reviewers for inclusion in the review. The full text of all studies of possible relevance was then obtained for independent assessment by the same reviewers. Any disagreement was resolved via discussion. Where resolution was not possible, a third reviewer was consulted. All studies meeting the inclusion criteria underwent validity assessment and data extraction. Reasons for exclusion were recorded (Table 2).

Data Extraction

The included studies provided information on the survival rates of teeth or implants as well as double crown-retained RDPs. Tooth or implant survival was defined as not needing extraction at the time of examination. Tooth or implant failure was defined as lost or hopeless teeth or implants. Survival of the double crown-retained RDPs was defined as being in function at the time of examination; failure was defined as no longer in function (eg, framework fracture, abutment or implant losses). Data extraction was performed independently by two reviewers using a standardized form.

Results

General Outcomes

The initial database search yielded 453 articles, and the manual search revealed another 59 titles. After an interreviewer discussion, 49 full-text articles were screened according to the inclusion and exclusion criteria. Finally, 11 studies were included (Figs 1 and 2).

No RCTs were identified. All selected studies were published in the last 17 years, with the majority published after 2000 (Table 1).

Because of the heterogeneity in the design of the different studies, it was not possible to perform a statistical analysis of the data obtained.

Table 1	Results of the Literature Search	

Database	Hits	Relevant hits	Included studies	Excluded studies
PubMed	334	24	4.	20.
	001		Krennmair et al ²⁰	Beschnidt et al ²⁹
			Krennmair et al ²¹	Dittmann and Rammelsberg ³⁰
			Weischer and Mohr ²²	Eitner et al ³¹
			Wöstmann et al ²³	Hoffmann et al ³²
				Hultén et al ⁵
				Igarashi and Goto ⁴
				Kaufmann et al ³³
				Landes et al ³⁴
				Longoni et al ³⁵
				Mengel et al ³⁶
				Mengel et al ³⁷
				Molin et al ³⁸
				Nickenig et al ³⁹
				Piwowarczyk et al ⁴⁰
				Wagner and Kern ⁴¹
				Weng and Richter ⁴²
				Wenz et al ⁴³
				Wenz and Lehmann ⁴⁴
				Widbom et al ⁴⁵
				Yamauchi and Kawano ⁴⁶
Medline	119	1	0	1:
				Zafiropoulos and Hoffmann ⁴⁷
Manual search and references	59	24	7:	17:
			Coca et al ²⁴	Bergman et al ³
			Heckmann et al ²⁵	Behr et al ⁴⁸
			Mock et al ²	Eisenburger and Tschernitschek ⁴⁹
			Nickenig et al ²⁶	Eisenburger et al ⁵⁰
			Nickenig and Kerschbaum ²⁷	Gernet et al ⁵¹
			Rehmann et al ²⁸	Heners and Walther ¹⁸
			Stark and Schrenker ⁶	Henrich and Kerschbaum ⁵²
				Hofmann and Ludwig ⁵³
				Kern and Wagner ⁵⁴
				Pöggeler ⁵⁵
				Rehmann et al ⁵⁶
				Rehmann et al ⁵⁷
				Rehmann et al ^{b8}
				Ross et al ^{b9}
				Studer et al ^{b1}
				Wenz et al ⁶²

Volume 24, Number 2, 2011 | 111

Reason for exclusion						
Case report	No cumulative survival rates for teeth, implants, or prostheses					
Beschnidt et al ²⁹	Bergman et al ³					
Hoffmann et al ³²	Dittmann and Rammelsberg ³⁰					
Longoni et al ³⁵	Eisenburger and Tschernitschek ⁴⁹					
Mengel et al ³⁷	Eisenburger et al ⁵⁰					
Yamauchi and Kawano ⁴⁶	Eitner et al ³¹					
Zafiropoulos and Hoffmann ⁴⁷	Heners and Walther ¹⁸					
Patients records only	Hofmann and Ludwig ⁵³					
Gernet et al ⁵¹	Hultén et al⁵					
Wenz et al ⁶²	Kaufmann et al ³³					
Same patient population	Molin et al ³⁸					
Pöggeler ⁵⁵ (same as Coca et al ²⁴)	Piwowarczyk et al ⁴⁰					
Rehmann et al ⁵⁶ (same as Wöstmann et al ²³)	Saito et al ⁶⁰					
Rehmann et al ⁵⁷ (same as Wöstmann et al ²³)	Weng and Richter ⁴²					
Rehmann et al ⁵⁸ (same as Wöstmann et al ²³)	Widbom et al ⁴⁵					
Survival rates for telescopic crowns and other attachments not separate	Zygoma implants used					
Behr et al ⁴⁸	Landes et al ³⁴					
Henrich and Kerschbaum ⁵²	Success rates only					
Kern and Wagner ⁵⁴	Mengel et al ³⁶					
Nickenig et al ³⁹	Wenz and Lehmann ⁴⁴					
Ross et al ⁵⁹	Wenz et al ⁴³					
Studer et al ⁶¹	No data on number of patients					
Wagner and Kern ⁴¹	Igarashi and Goto ⁴					





Fig 1 (left) Search strategy and results.

Fig 2 (above) Dissection of search outcomes.

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Table 3Survival Rates of Teeth and RDPs

						Survival ra	ate
Study	Study design	Observation period (y)	No. of patients	No. of teeth	RDP design (no.)	Teeth (%)	RDP (%)
Nickenig et al ²⁶	RS	5	39	_	Tc (45)	88	_
Nickenig and Kerschbaum ²⁷	RS	5 8	85	402	Tc (105)	95 81	—
Stark and Schrenker ⁶	PS	6	68	258	Tc (68)	90	—
Coca et al ²⁴	RS	7-8	92	236	Tc (106)	Maxilla: 68 Mandible: 73	—
Rehmann et al ²⁸	RS	4	84	168	Tc (84)	90	90
Mock et al ²	PS	10	92	299	Tc (105)	Maxilla: 83.5 Mandible: 60.6	—
Wöstmann et al ²³	RS	5.3	463	1,758	Tc (554)	95.3	95.1

RS = retrospective study; PS = prospective study; Tc = telescopic crowns.

Table 4 Survival Rates of Implants and RDPs

							Surviva	rate
Study	Study design	Observation period (y)	No. of patients	No. of implants	Implants	RDP design (no.)	Implants (%)	RDPs (%)
Weischer and Mohr ²²	RS	9	24	111	Frialit 2, IMZ, Brånemark	Tc (24) Mandible	97	95
Heckmann et al ²⁵	PS	10.4	23	46	ITI	Tc (23) Mandible, R	100	100
Krennmair et al ²¹	PS	3	12	24	Camlog	Tc (12) Mandible, R	100	100

RS = retrospective study; PS = prospective study; Tc = telescopic crowns; R = resilient telescopic crowns.

Survival Rates

Teeth and Tooth-Supported Double Crown-Retained RDPs. The literature search yielded seven studies that presented data on the longevity of teeth supporting double crown-retained RDPs. Two prospective and five retrospective studies were found with observation periods between 4 and 10 years. A total of 923 subjects with a mean age at baseline ranging from 43.4 to 62.0 years were examined clinically,^{2,27} and more than 3,121 teeth with telescopic crowns were assessed. The survival rates are shown in Table 3.

Only two retrospective studies provided information about the survival rate of telescopic crownretained RDPs. The mean age of the patients at baseline ranged from 43.4 to 58.8 years.^{23,28} The survival rates after 4 and 5.3 years are presented in Table 3.

Implants and Implant-Supported Double Crown-Retained RDPs. The survival rates of implants and implant-supported double crown-retained RDPs were assessed in two prospective studies and one retrospective study, with observation periods between 3 and 10.4 years (Table 4).^{21,22,25} A total of 59 subjects with a mean age at baseline ranging from 63.2 to 74.1 years were examined.^{21,25} One hundred eighty-one implants with mainly internal connections were used to support the prostheses. The inner crowns were either cement- or screw-retained. To increase retention, one study presented data using an additional attachment system.²¹ The RDPs were mainly retained by nonrigid telescopic crowns. The outcomes are presented in Table 4.

Teeth, Implants, and Tooth and Implant– Supported Double Crown–Retained RDPs. Only one retrospective study provided information regarding the longevity of teeth, implants, and telescopic crownretained RDPs.²⁰ The clinical examination included 22 subjects with a mean age at baseline of 63.7 years. All implants had internal connections and were placed by means of a conventional protocol. The 22 telescopic crown–retained RDPs were fabricated with an additional attachment system to increase retention. All patients participated in a strict recall program. The survival rates of teeth, implants, and RDPs are shown in Table 5.

	Study	Observation	No of 1	No of	No of		RDP design		Survival rate	
Study	design	period (y)	patients	teeth	implants	Implants	(no.)	Teeth (%)	Implants (%)	RDPs (%)
Krennmair et al ²⁰	RS	3.2	22	48	60	Frialit-2 Xive Camlog root-line	Tc (22) Maxilla	100	100	100

Tab	le 5	Survival	Rates	of	Teeth,	Implants,	and RDPs
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RS = retrospective study; Tc = telescopic crowns.

Discussion

Despite that the double crown attachment system is costly, technique-sensitive, and even considered an overtreament by some clinicians, it is used regularly in some parts of the world whenever an RDP is indicated. Advocates of using such an attachment system tout its advantages and predictability over conventional RDPs.

In the present review, the survival rates of toothsupported double crown-retained RDPs were 90.0% and 95.1% after 4 and 5.3 years, respectively.23,28 Studies have shown that conventional RDPs, ie, clasp-retained dentures combined with crowns, have survival rates between 40% and 84% after 5 years, as well as 20% and 59% after 10 years.63,64 No survival rates of (crowned) teeth supporting clasp-retained RDPs are available. Although the reported survival rates for the double crown system seem to be higher than those for conventional RDPs, the evidence is weak. The majority of the studies on (tooth-supported) double crown-retained RDPs had a retrospective design. Because of an insufficient number of studies, as well as heterogeneity in study design, a statistical analysis of the data was not possible. Therefore, the current systematic review evaluated the reliability of each treatment modality according to the number and quality of relevant studies identified. Hence, there is no evidence that clasp-, (semi-) precision attachment-, or bar-retained RDPs provide better clinical long-term data than double crown-retained prostheses.^{26,49,50,60,61,63–70}

When compared with simple clasp-retained RDPs, double crown-retained dentures provide the advantage of good patient acceptance,⁷¹ the possibility of extension after tooth extraction,⁷² the compensation of nonparallel tooth axes,⁷² and better functionality.^{7,13,43} However, teeth restored with double crowns tend to have an overcontoured design.⁶¹ The great reduction of tooth substance (1 to 1.2 mm labially), the higher risk of root canal treatment,¹⁹ the increased costs,⁷³ the potential difficulties at the beginning because of the patient's handling of the device,¹³ and the challenging technical production⁷² are all disadvantages of double crown-retained RDPs. This might be the reason why clasp-retained prostheses are more commonly used worldwide compared with double crown-retained dentures.

Several authors have assessed factors that might influence the survival rate of teeth supporting double crown-retained RDPs. These factors included the type of double crown system, as well as the number, position, and biologic aspects of the teeth.^{2,4,5,18,23,30,38,40,43,50,74} In a retrospective clinical study, 385 abutment teeth were provided with either conical, rigid, or nonrigid telescopic crowns. After a mean service time of 6.3 years, the authors reported that the design of the double crowns had no significant impact on survival rate.38 Since no additional data are available, no information can be given regarding the influence of double crown type on the survival rates of teeth supporting double crownretained RDPs. Furthermore, several authors agreed that survival rates of teeth in severely reduced dentitions differ significantly from those in dentitions with more than three remaining teeth.^{2,4,5,18,23,50,74} In a retrospective longitudinal study, it was shown that the 5-year survival rate of double crown-retained RDPs was dependent on the number of abutment teeth.³ This is in agreement with another study that indicated that having only a few abutment teeth (one to three abutments) and large extensions is less favorable with regard to the distribution of loading forces and is a predictor of early failure.⁵ It seems that three or more teeth supporting double crown-retained dentures can have a positive impact on the survival rate of teeth. In contrast, data reported in another clinical study showed the reverse.⁴³ More studies (RCTs) are needed to validate the higher tooth survival rate for double crown-retained RDPs when supported by three or more teeth.

Furthermore, the influence of the location of supporting teeth on the survival rate of double crownretained prostheses seems to be controversial as well. One study reported that the survival rate of teeth used for double crown-retained RDPs in the

© 2010 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER. maxilla is lower than that in the mandible (maxilla: 68%, mandible: 73% [after 7 to 8 years]).²⁴ In contrast, another study showed a survival rate of 83.5% for the maxilla and 60.6% for the mandible after 10 years.² Furthermore, one study showed that posterior abutment teeth (13.6%) have a significantly higher risk of tooth loss compared to anterior ones (5.3%) after an observation period of 5 years.³⁰ Again, more studies looking at the influence of the location on the survival rate of tooth-supported double crown-retained RDPs are needed.

The influence of root canal treatment on the survival rate of teeth supporting double crown-retained prostheses is also controversial. In a retrospective clinical study, significantly higher failure rates were reported for teeth with root canal treatment (20%) compared to vital teeth (5.7%) after an observation period of 6.3 years.³⁰ Another study indicated a greater risk for failure when root-filled teeth were used to support conical crown-retained RDPs.38 However. no statistical analysis was performed in this specific study. In another prospective study, the fracture and extraction rates for nonvital teeth were shown to be twice as high as those for vital ones supporting telescopic crown-retained RDPs after an observation period of 3 years.⁷⁵ Conversely, one retrospective study reported a higher failure rate for vital teeth (60%) than nonvital ones (40%).40 Similarly, the authors did not carry out a statistical analysis of the data or provide reasons why the findings for vital teeth were worse. It can be concluded that nonvital but successfully treated teeth yield high survival rates, generally over 90%, after 10 years,⁷⁶ and therefore can be used as abutments for double crown-retained dentures. Although the survival rates of endodontically treated teeth are reported to be less than those for vital teeth in most studies, the current evidence is obviously weak. To provide more information about this issue, it is necessary to conduct well-designed comparative longterm studies.

Good oral hygiene is a prerequisite for the longterm success of dental restorations.^{2,4,6,23,24} For double crown-retained dental prostheses, it was shown that the risk of loss of function was 5.3 times lower for patients enrolled in a recall program with professional prophylaxis.²³

In cases of improper distribution of abutment teeth, implants can be placed to increase the number of abutments and improve their distribution. Prostheses can be retained or supported by splinted or unsplinted implants. It was reported in an RCT that implants of mandibular overdentures had an excellent prognosis irrespective of the attachment system used.⁷⁷ This is in agreement with the findings of a systematic

literature review assessing the influence of attachment systems on the survival rate of implants used to retain or support prostheses in the maxilla or mandible.78 This systematic literature review revealed three double crown studies on implants placed in the mandible, showing survival rates between 97% and 100% after 3 to 10.4 years.^{21,22,25} The authors reported that implant failures were a result of peri-implantitis and occlusal overload. The survival rates of double crown-retained RDPs placed in the mandible using implants for support were between 95% and 100% after an observation period between 9 and 10.4 years (see Table 4).^{21,22,25} In one study, a patient was unable to adapt to his restoration and did not wear his prosthesis. Unfortunately, no data were found on implants or double crowns used in the maxilla. Since no RCTs reporting the survival rates of implant-retained or implant-supported double crown-retained RDPs exist, no information can be given concerning the longterm outcomes.

Unfortunately, the use of implants as additional retainers for RDPs in partially edentulous patients has rarely been discussed in the literature.^{33,79-83} This systematic review revealed a combined survival rate of abutments and double crown-retained RDPs in the maxilla of 100% after a mean observation period of 3.2 years.²⁰ No data for the mandible is available at present. While long-term data is missing, the success of implant and tooth–supported double crownretained dentures needs further investigation.

Conclusion

The present data does not provide sufficient information on the long-term outcome of double crownretained RDPs. Further studies based on a higher level of evidence (RCTs) are needed to validate the outcomes of this treatment modality.

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115

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116 | The International Journal of Prosthodontics

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