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A Systematic Review of the Clinical Performance of Tooth-Retained and Implant-Retained Double Crown Prostheses with a Follow-Up of ≥3 Years

Rohini Verma, DMD, Dr. med. dent.,[1] Tim Joda, DMD, Dr. med. dent.,[2,3] Urs Brägger, DMD, Prof. Dr. med. dent.,[4] & Julia-Gabriela Wittneben, DMD, Dr. med. dent., MMSc[5]

[1]Former ITI Scholar, Division of Fixed Prosthodontics, University of Bern, Bern, Switzerland
[2] Assistant Professor, Division of Fixed Prosthodontics, University of Bern, Bern, Switzerland
[3]Assistant Professor, Department of Prosthetic Dentistry, University of Hamburg, Hamburg, Germany
[4]Professor, Division of Fixed Prosthodontics, University of Bern, Bern, Switzerland
[5]Assistant Professor, Division of Fixed Prosthodontics, University of Bern, Bern, Switzerland

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Correspondence
Urs Brägger, Department of Fixed Prosthodontics, University of Bern, Freiburgstrasse 7, CH-3010, Bern, Switzerland. E-mail: urs.braegger@zmk.unibe.ch

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Abstract

Purpose: The objective of this review was to systematically screen the literature for data related to the survival and complication rates observed with dental or implant double crown abutments and removable prostheses under functional loading for at least 3 years.

Materials and Methods: A systematic review of the dental literature from January 1966 to December 2009 was performed in electronic databases (PubMed and Embase) as well as by an extensive hand search to investigate the clinical outcomes of double crown reconstructions.

Results: From the total of 2412 titles retrieved from the search, 65 were selected for full-text review. Subsequently, 17 papers were included for data extraction. An estimation of the cumulative survival and complication rates was not feasible due to the lack of detailed information. Tooth survival rates for telescopic abutment teeth ranged from 82.5% to 96.5% after an observation period of 3.4 to 6 years, and for tooth-supported double crown retained dentures from 66.7% to 98.6% after an observation period of 6 to 10 years. The survival rates of implants were between 97.9% and 100% and for telescopic-retained removable dental prostheses with two mandibular implants, 100% after 3.0 and 10.4 years. The major biological complications affecting the tooth abutments were gingival inflammation, periodontal disease, and caries. The most frequent technical complications were loss of cementation and loss of facings.

Conclusions: The main findings of this review are: (I) double crown tooth abutments and dentures demonstrated a wide range of survival rates. (II) Implant-supported mandibular overdentures demonstrated a favorable long-term prognosis. (III) A greater need for prosthetic maintenance is required for both tooth-supported and implant-supported reconstructions. (IV) Future areas of research would involve designing appropriate longitudinal studies for comparisons of survival and complication rates of different reconstruction designs.

The rehabilitation of severely compromised, partially edentulous patients with only a few remaining teeth is challenging.[1] Among other factors such as patient preference and economic aspects, the available prosthetic options depend on the strategic decision to maintain a certain number of teeth with a good prognosis, or to extract all remaining teeth in a jaw, or to place implants at prosthetically favorable positions.

Partially edentulous patients with a reduced number of remaining anchor teeth can be restored successfully with double crown reconstructions. These reconstruction types are specific hybrid compositions of fixed abutments (as primary inner crowns) and removable prostheses (as secondary outer frameworks). Depending on the retention mechanism, double crown removable dental prostheses (RDPs)[2] can be classified into three subgroups: telescopic parallel crowns, conical double crowns, and double crowns with additional retention modifications. Telescopic crowns achieve retention using friction of parallel-milled surfaces, and conical crowns exhibit friction

only when completely seated using a "wedging effect," whereas the double crown with clearance fit exhibits no friction or wedging during insertion or removal. Retention may also be achieved by using additional attachments (e.g., the TC-SNAP system [Marburg double crown]).[3] Materials used for the inner and outer crowns are gold alloys, Cr–Co metal alloys, titanium, and zirconia.

The most important advantage of double crown reconstructions is the possibility to restore a dentition using a few remaining teeth located in unfavorable positions for other prosthetic reconstructions. Missing hard and soft tissue can be masked by white acrylic veneering material or pink ceramic. Due to the coverage of the abutment teeth with the denture, the esthetic outcome is also more favorable compared to conventional partial dentures with clasps. In case of a failing abutment tooth, the reconstruction can more easily be modified compared to a fixed dental prosthesis (FDP).[2]

The major disadvantages are the high demand on precision and special skills required of both the dental technician and the clinician in the fabrication of double crown reconstructions, consequently increasing the total cost of the prosthesis. Very often, a bulky overcontoured shape of the reconstruction may interfere with home care and supportive periodontal therapy.

The commonly used attachment systems connecting overdentures and implants have included bars of different designs, anchors, magnets, and locator systems. The concept of telescopic retention of dentures has also been applied in implant dentistry. The resilient (nonrigid) telescopic crown on implants was first introduced in 1989.[4] The choice of connector system may be influenced by jaw anatomy, the available space in the vertical and/or horizontal dimension, cost effectiveness, and the patient's economic status and expectations. Telescopic crowns on implants are effective in prosthesis stabilization with regard to horizontal forces in cases of advanced atrophy of the alveolar crest.[5]

Strategic clinical decisions during treatment planning should be supported by evidence-based facts. Today, a series of systematic reviews provide pooled data on the estimated 5-year survival rates on teeth or implants.[6-12] However, especially for observation periods of 10 years or more, the estimated cumulative survival and success rates were based on a few studies and for fewer than 100 reconstructions. There is also a paucity of similar data on double crown prostheses on teeth and implants.[6-12]

A recent review displayed survival rates for tooth-supported telescopic abutments in a widespread range between 60.6% and 95.3% after an observation period of 4 to 10 years. The survival rates of telescopic RDPs varied between 90.0% and 95.1% after 4 and 5.3 years, respectively.[13] However, these data are limited to English- and German-language publications in correlation with an electronic and selective manual search in prosthetic-oriented journals only. Dental implant journals were not involved in the manual search strategy. Furthermore, the results are presented for double crown retained reconstruction types in general without a special differentiation within the diverse retention modalities.

Therefore, the objective of this systematic review was to extend the electronic screening of the dental literature including a broad hand search in all relevant prosthetic and implant journals without language restrictions on data related to survival and complications observed with dentate or implant-supported double crowns and RDPs—subdivided for parallel telescopic and conical double crown retained reconstructions as well as special additional friction elements in combination with telescopic prostheses—that had been in function for a period of at least 3 years.

Materials and methods

Search strategy

A search in the MEDLINE (PubMed) and EMBASE databases as well as an extensive hand search in the period from January 1966 to December 2009 was performed. Publications in all languages in peer-reviewed journals were considered. The search strategy applied was a combination of MESH terms and free-text words in simple or multiple conjunctions: "telescopic crown," "double crown," "crown and sleeve coping," "telescopic prosthesis," "telescopic copings," "telescopic copings and overdentures," "telescopic crown and overdentures," "conical crown," "Marburg double crown," "telescopic implant prosthesis," "telescopic abutment retainer," "telescopic abutments," and "telescopic abutment copings."

Selection criteria

Randomized controlled trials (RCTs) and prospective and retrospective cohort studies with a mean follow-up time of at least 3 years were included. The inclusion criteria were

- Mean follow-up time of at least 3 years.
- Case series with 10 or more patients.
- Studies with tooth- or implant-supported RDPs.
- Studies on completely or partially edentulous patients.
- Studies with clinical examinations at the follow-up visits.
- Studies with implants irrespective of the surgical technique (submerged or nonsubmerged healing), natural/regenerated bone, sinus elevations, and the timing of implant placement and loading.

The following exclusion criteria were used

- animal studies;
- in vitro studies;
- studies based on questionnaires, records, reviews, clinical reports, case series with fewer than 10 patients involved, surveys, and interviews; and
- zygomatic implants, transmandibular implants, and bladevent implant systems.

Definitions

Information on the survival rates of the reconstructions and of biological and technical complications were retrieved. Survival was defined as the reconstruction remaining in situ at the follow-up examination visit irrespective of its condition.

Biological complications for tooth-supported reconstructions covered dental caries, loss of pulp vitality, and periodontal disease progression. Biological complications for implant-supported reconstructions were characterized by a biological process affecting the supporting tissues. Soft tissue

complications, periimplantitis, bone loss exceeding 2 mm, and esthetic complications were included in this category.

Technical complications for tooth-supported reconstructions encompassed loss of retention, abutment tooth fractures, and fractures or deformations of the framework or veneers. Technical complications for implant-supported reconstructions encompassed screw or abutment loosening, mechanical damage or fractures of implants, fracture of implant components and/or the telescopic outer suprastructures of the framework, or deformations of veneers.

Validity assessment

Two reviewers (RV, JW) independently screened all titles and abstracts and selected the papers through a systematic search process. The discrepancies between the reviewers were resolved by discussion to finalize the articles for full-text evaluation and for data collection.

Data extraction

The outcome variables included the survival and complication data observed in:

- telescopic crowns and RDPs on teeth, and
- telescopic abutments and overdentures on implants.

From the included papers, the following information was extracted: the study parameters (author[s], year of the study), the population parameters (number of patients, mean age of the patients, mean observation time), details on the telescopic teeth/implants (number of teeth/implants, teeth/implant survival [%], teeth/implant biological and technical complications [%]), and data on the tooth/implant-supported dentures (number of dentures, denture survival [%], denture complications [%]). Subsequently, the major findings related to prosthesis design and design of the telescopic retainers were noted and grouped together. When information in the studies was lacking, the corresponding authors were contacted by telephone or e-mail.

Results

Of the 2412 titles chosen from the search, 65 were selected for full-text review based on the information given in the abstract (Fig 1). From the 65 full-text articles, 17 papers were included for data extraction. Data on the total exposure time is essential for the calculation of the estimated survival and success rates of the abutments and reconstructions. Due to the lack of information with regard to the exposure time in the papers included in this review, pooling of the data and estimation of the cumulative survival and complication rates in years was not feasible. The observations from the 17 publications were grouped according to the type of abutment supporting the prosthesis for teeth and implants and the retention design of the telescopic crowns.

Tooth-supported telescopic reconstructions

Parallel retention design of the telescopic crowns

In a prospective clinical study, Mock et al[14] presented data on 92 patients restored with 92 dentures on 299 parallel telescopic crowns observed over a mean follow-up period of 7.4 years

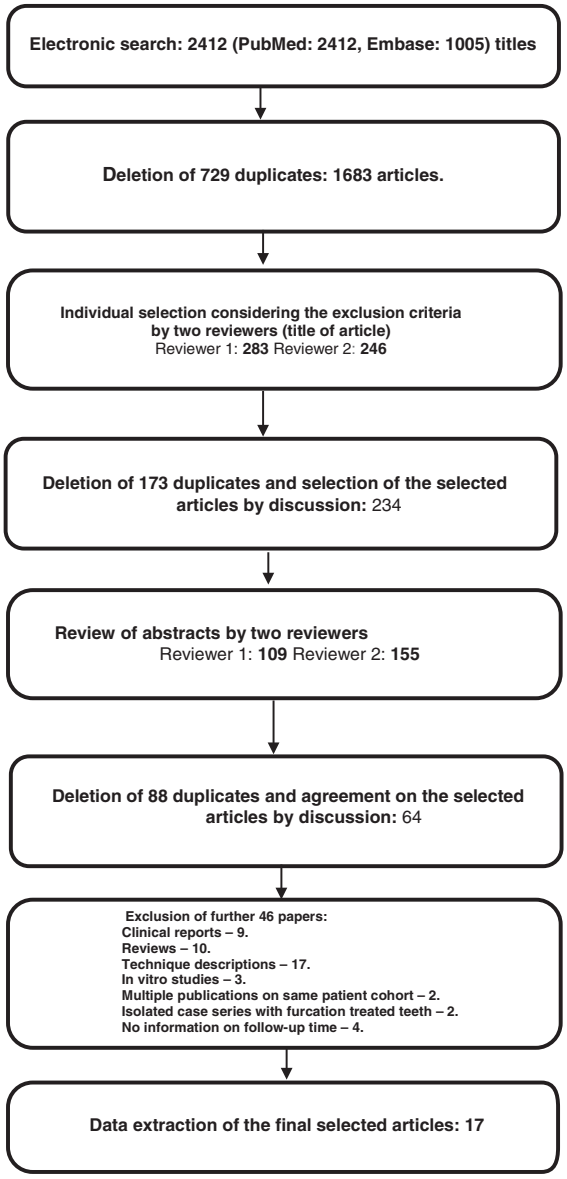

Figure 1 Search design and strategy.

(Table 1). Of the telescopic crowns, 37% had to be recemented, and 25% of the dentures had problems with corrosion and degradation between acrylic material and metal. The Kaplan-Meier probability for the survival of abutment teeth was 97.8% after 1 year, 86.3% after 5 years, and 72.4% after 10 years of functional loading.

In a retrospective study, Wöstmann et al[15] evaluated 554 telescopic removable partial dentures (RPDs) on 1758 primary telescopic crowns in 463 patients. During the mean observation period of 5.3 years, 66 (3.8%) abutment teeth were extracted, and 26 (4.7%) dentures were reported as failures. The estimated survival probability after 5 years was 95.3% for the abutment teeth and 95.1% for the RDPs. The estimated 5-year survival probability for dentures with only one abutment was 70.9% compared to 90.4% with two, 95.0% with three, and 97.9%

with four abutments. It was summarized that the number of abutments supporting the prosthesis had a considerable impact on the survival of the denture. The main abutment complications observed were the 362 (20.6%) recementations. Three hundred and fifty-nine dentures were noted to undergo at least one postinsertion modification procedure, and 192 (34.8%) denture relinings and 149 (26.9%) loss of facings were recorded.

Conical retention design of the telescopic crowns

In another retrospective evaluation, Wagner and Kern[16] investigated the 10-year failure rates of different RPD designs in 74 patients with 51 conical crown retained dentures (CCRDs), 22 clasp-retained dentures (CRPDs), 7 RPDs, 17 overdentures, and 4 other denture designs (Table 2). At reexamination, 39 CCRDs were present. RPDs had a higher failure rate (66.7%) than CCRDs (33.3%) and CRPDs (44.8%). The major technical problem for the telescopic dentures was a loss of retention observed in 13 (25%) dentures.

The risk of vitality loss in the abutment teeth after the insertion of CCRDs was evaluated by Walther[17] in 655 patients with 787 dentures (2478 abutments) for up to 8 years. During the observation time, 183 abutment teeth in 134 patients lost vitality and were treated endodontically. Additionally, 916 (37%) abutments had an advanced periodontal breakdown, and 34 (1.3%) fractures occurred.

In 57 patients, 62 telescopic dentures supported by 188 abutments were observed for a period of 3.4 years.[18] Twelve (19.3%) dentures and 33 (17.5%) abutments were reported as failures. The denture failures occurred due to abutment extraction (4) or conversion to root anchor-retained dentures (8). Forty-seven (75%) denture failures had occurred within 18 months postinsertion. In the CDA quality ratings, 80.6% of the inner crowns and 92.3% of the outer constructions were satisfactory for their anatomic form, color, surface, and marginal integrity. At the follow-up examination, 29 (47%) dentures were modified postinsertion, and 23 (37%) dentures were found to have an unacceptable retention.

Technical and biological complications of 530 abutments (probing pocket depth, mobility, secondary caries, and inflammatory changes) and 152 dentures (occlusion, retention, and frequency of relining and repair) were evaluated over a mean follow-up of 12 years.[19] The telescopic dentures were grouped according to the Kennedy classification as: 29 class I, 54 class II, and 45 class III dentures supported by 170, 148, and 172 abutments, respectively. Twenty-four dentures supported by 40 abutments were grouped as the few remaining group. Eighty-four (13.7%) abutments and 27 (12.8%) denture failures were observed. Forty-nine (9.2%) abutments were carious, and 40 (7.5%) demonstrated periodontitis at the follow-up examination. The main denture complications were 55 (36.1%) relinings, 22 (14.4%) fractures of denture teeth, and 28 (18.4%) fractures of facings.

Ninety-seven telescopic reconstructions supported by 445 abutments in 97 patients were investigated over a period of 5 years.[20] The criteria assessed were abutment failures, tooth mobility, mean probing depths, and radiological bone loss. A total of 30 (6.7%) abutment teeth were extracted (18 vital, 12 nonvital), and 5 (5.1%) dentures failed. Seventy-six (17%)

Table 1 Studies with parallel retention design of the telescopic crowns

				Abutments			Dentures		
Study	No. of patients	Mean age (years)	Mean observation time (years)	No. of abutments	Abutment failures (%)	Abutment complications (%)	No. of dentures	Denture failures (%)	Denture complications (%)
Mock et al (2005)[14]	92	62.0	7.4	299	Kaplan-Meier estimates: 2.2% at 1 year, 14.7% at 5 years, 27.6% at 10 years	110 (37%) recementations	92 (50 Max, 42 Man)	NR	23 (25%) degradation between acrylic/ metal and corrosion
Wöstmann et al (2007)[15]	463	58.8	5.3 ± 2.9	1758	66 (3.8%) Survival probability after 5 years is 95.3%	362 (20.6%) recementations	554 (399 Class I, 82 class II, 18 class III)*	26 (4.7%). Survival probability after 5 yrs is 95.1%. Estimated 5-year survival rates of 70.9% (single abutment), 90.4% (two abutments), 95.0% (three abutments) and 97.9% with four abutments	192 (34.8%) relinings, 359 (64.8%) dentures treated at least once, 149 (26.9%) loss of facings

Max = maxilla; Man = mandible; NR = not reported

*Class I, Class II, Class III, Class IV according to Kennedy Classification.

Table 2 Studies with conical retention design of the telescopic crowns

Study	No. of patients	Mean age (years)	Mean observation time (years)	Abutments: No. of abutments	Abutments: Abutment failures (%)	Abutments: Abutment complications (%)	Dentures: No. of dentures	Dentures: Denture failures (%)	Dentures: Denture complications (%)
Wagner & Kern (2000)[16]	74	64.6	10.0	311	82 (26.4%)	40 (12.9%) caries	51	13 (33.3%)	13 (25%) with loss of retention
Walther (1995)[17]	655	58.8	Up to 8 years	2478 (1092 Max, 891 Man)	NR	916 (37%) advanced periodontitis, 34 (1.3%) fractures, 183 (7.3%) endodontic treatments	787	NR	NR
Hulten et al (1993)[18]	57	67.0	3.4	188	33 (17.5%)	27 (14.3%) caries of inner crowns	62	12 (19.3%) 47 (75%) failures occurred within 18 months of insertion	29 (47%) modified post insertion. 23 (37%) had loss of retention
Igarashi & Goto (1997)[19]	NR	62.0	12.0	530 (170 class I, 148 class II, 172 class III, 40 remaining)*	84 (13.7%)	49 (9.2%) secondary caries, 40 (7.5%) periodontitis.	152 (29 Class I, 54 class II, 45 class III, 24 few remaining)*	27 (12.8%)	55 (36.1%) relinings, 22 (14.4%) fractures of denture teeth, 28 (18.4%) fractures of facings
Piwowarczyk et al (2007)[20]	97	59.8	4.9 ± 2.8	445 (231 Max, 214 Man)	30 (6.7%)	76 (17%) non-vital	97 (56 Class I, 31 class II, 10 class III)*	5 (5.1%)	NR
Stark & Schrenker (1998)[21]	68	60.0	Up to 6 years	258	10 (3.8%)	34 (13.1%) recementations	68	1 (1.4%)	31 (45%) repairs or relining
Bergman et al (1996)[22]	18	68.6	6.1 to 7.8	78	7 (8.9%)	3 (3.8%) grade 3 mobility, 21 (26.9%) surfaces with caries, 25 (32%) recementations	18	8 (30.7%) 78.3% survival rate of the dentures after 6.1 to 7.8 years.	17 (94%) acrylic resin repairs
Reitmeier & Reitmeier (1976)[23]	57	55.0	4.9	180	31 (17.2%)	Tooth mobility	67 (41 Max, 26 Man)	0	NR

Max = maxilla; Man = mandible; NR = not reported.

*Class I, Class II, Class III, Class IV according to Kennedy Classification.

abutments were nonvital at reexamination. The denture failures were attributed to periodontal disease and fractures, and the incidence was higher in the maxilla. A favorable clinical prognosis was concluded for conical crowns supporting the RPDs.

In a clinical study by Stark and Schrenker,[21] 68 dentures supported by 258 abutment teeth were followed for a period of 6 years. The complications observed were 31 (45%) denture relinings, 34 (13.1%) recementations of the telescopic primary crowns, and the presence of inflammation in the denture-bearing area. Ten (3.8%) abutments and one (1.4%) denture failed during the observation period. The Kaplan-Meier probability for the survival of abutments after insertion was 90% after 6 years.

Bergman et al[22] reexamined 18 patients with 18 dentures supported by 78 double crowns in a follow-up period from 6.1 to 7.8 years. The original patient pool consisted of 25 patients with 26 dentures. Of the eight restorations missing in the final reevaluation, four had been modified prosthodontically during the observation period. Seven (8.9%) abutments and eight (30.7%) dentures failed, resulting in a 78.3% survival rate of the dentures. In the complication group, 25 (32%) inner copings were recemented, 3 (3.8%) abutments had grade 3 mobility, 21 (26.9%) surfaces were carious, and 17 (94%) acrylic dentures were repaired.

A study by Reitemeier and Reitemeier[23] evaluated 67 dentures with 180 abutment teeth after a mean observation time of 4.9 years. No denture failures were observed, although 31 (17.2%) telescopic anchor teeth were extracted over the follow-up period. Abutment tooth mobility was the main complication reported. Information on denture complications was missing completely.

Reconstructions with a conical compared to a parallel retention design of telescopic crowns

Behr et al[24] assessed the effect of the abutment retention design (conical vs. parallel) on the incidence of technical complications (Table 3). In 117 patients, 43 dentures on 160 conical double crowns and 74 dentures on 251 parallel design telescopic crowns were followed for a mean time of 5.2 years and 4.6 years, respectively. Technical problems occurred more frequently in patients with a conical design denture (48.8%, n = 21) compared to patients with a parallel retention design (34.2%, n = 25). This difference was, however, not significant. Parallel crowns demonstrated 19 (7.5%) losses of cementation versus 8 (5%) observed with conical design. Failures with parallel CCRDs included: four (5.4%) fractures of artificial teeth and two (2.7%) of metal frameworks. In the conical crown dentures, four (2.5%) loss of facings, three (6.9%) fractures of denture teeth, three (6.9%) fractures of metal framework, three (4.6%) fractures of resin frameworks, and one (0.6%) fracture of soldering were recorded.

Modified retention design of the telescopic crowns

In another study, using the CDA criteria, the retention, design, mucosal health, wear, occlusion, and articulation of telescopic reconstructions were graded for 72 participants wearing 75 dentures (368 primary crowns) over a mean follow-up of 3.8 years (Table 4).[25] The retention design was modified with a

Table 3 Study comparing the parallel to the conical retention design of the telescopic crowns

				Abutments			Dentures		
Study	No. of patients	Mean age (years)	Mean observation time (years)	No. of abutments	Abutment failures (%)	Abutment complications (%)	No. of dentures	Denture failures failures (%)	Denture complications (%)
Behr et al (2000)[24]	117	62.2	PCRD: 4.6 ± 1.6, CCRD: 5.2 ± 1.3	411 (PC: 251, CC: 160)	NR	PC: 19 (7.5%) loss of cementation. CC: 8 (5%) loss of cementation	117 (74 PCRDs 43 CCRDs with conical crowns)	PCRD: four (5.4%) fractures of denture teeth, two (2.7%) fractures of metal framework. CCRD: three (6.9%) fracture of artificial teeth, four (2.5%) loss of facings, one (0.6%) fracture of soldering, three (6.9%) fracture of resin framework, two (4.6%) fracture of resin framework	PCRD: 34.2% technical problems CCRD: 48.8% technical problems

CCRD = conical crown retained dentures; PCRD = parallel crown retained dentures; NR = not reported; PC = parallel crowns; CC = conical crowns.

Table 4 Studies with a modified retention design of the telescopic crowns

				Abutments			Dentures		
Study	No. of patients	Mean age (years)	Mean observation time (years)	No. of abutments	Abutment failures (%)	Abutment complications (%)	No. of dentures	Denture failures failures (%)	Denture complications (%)
Widbom et al (2004)[25]	72	67.0	3.8	368 (272 Max, 96 Man)	24 (7%)	22 (5.9%) recementations, 11 (2.9%) endodontic treatments, 22 (5.9%) caries, 43 (11.6%) periodontitis, 14 (3.8%) with grade 2 and 3 mobility	75	1 (1.3%), 4 (5.3%) framework fractures, survival rate of dentures: 96%	NR

Max = maxilla; Man = mandible; NR = not reported.

2° angulation and a chamfer at the margin of the inner crown. During the observation period, 1 (1.3%) denture and 24 (7%) telescopic abutments were failures, rendering a denture survival rate of 96%. Twenty-two (5.9%) abutment teeth had loss of cementation, 11 (2.9%) endodontic treatments, 22 (5.9%) caries, 43 (11.6%) periodontitis, and 14 (3.8%) were with grade 2 and 3 mobility. Additionally, 4 (5.3%) framework fractures were observed.

Retention design of the telescopic crowns not specified

Saito et al[26] evaluated a total of 91 RPDs of different denture designs; of these, 27 telescopic dentures (132 abutments) had been in function for 2 to 11 years (Table 5). The aim was to assess the effect of the denture designs on the failure and complication rates. Over a mean period of 8.1 years, the telescopic reconstructions had 15 (11.4%) abutment failures, the highest among the different denture designs. The major abutment complications were: 23 (17.4%) displacements of the dowel and core, 12 (9%) displacements of the inner copings, 2 (1.5%) displacements due to other reasons, and 2 (1.5%) perforations of inner copings.

In a study by Coca et al,[27] 92 patients, (106 dentures [236 abutments]) were examined for complications and failures in abutments (mobility, pocket probing depth, gingival recession, tooth vitality, crown margins, tarnishing of the alloy) and dentures (denture hygiene, tarnishing, evidence of cracks and repair). Over a follow-up of 2 to 11 years, 33 (13.9%) abutment teeth failed, with higher frequencies observed in the maxilla. The main abutment complications were: 14 (6%) nonvital, 24 (10%) caries, 169 (72%) periodontitis, 118 (50%) gingival recession, and 4 (1.6%) endodontic treatments. A lower survival rate was observed for the maxillary (86%) compared to the mandibular abutments (92%). Denture failures were noted due to cracks and fractures in 1 maxillary (5%) and 23 mandibular (21.5%) dentures. Occlusal repairs in 23 (22%) maxillary and 20 (18.5%) mandibular dentures and 36 (33.9%) metal tarnishings constituted the main complications.

Implant-supported telescopic reconstructions

Eitner et al[28] compared 169 implants with bar constructions in 51 (46.8%) patients to 154 telescopic implants supporting mandibular overdentures in 58 (53.2%) patients (Table 6). Seventeen (10.4%) implants with bar attachments demonstrated a bone loss of 25% to 50% versus 3 (2.1%) implants supporting the telescopic dentures. Eleven (6.5%) implants with bar attachments and eight (5.2%) implants with telescopic reconstructions failed. No overall advantages were concluded for either of the two retention systems in the study.

Heckmann et al[5] investigated the soft and hard tissue changes as well as prosthesis function for mandibular telescopic overdentures supported by two implants after a period of 10 years. In 23 patients, 46 solid screw implants were placed in the mandibular anterior region and loaded after 3 months. Sixteen of the primary crowns were cemented, and 30 were screw retained. The implant complications were: one (2.8%) periimplantitis, three (6.3%) gingivitis, four (8.6%) recementations of primary copings, and five (10.8%) occlusal screw loosenings. One (2.1%) implant failed, five (21.7%) overdentures were relined, and in

Table 5 Studies with an unspecified retention design of the telescopic crowns

				Abutments			Dentures		
Study	No. of patients	Mean age (years)	Mean observation time (years)	No. of abutments	Abutment failures (%)	Abutment complications (%)	No. of dentures	Denture failures (%)	Denture complications (%)
Saito et al (2002)[26]	22	52.1	8.1 ± 2.4	132	15 (11.4%)	Displacements: 23 (17.4%) dowel and core, 12 (9%) inner coping, 2 (1.5%) due to other reasons, 2 (1.5%) perforations of inner copings	27	NR	NR
Coca et al (2000)[27]	92	30 to >80 years	2 to 11	236 (99 Max, 137 Man)	33 (13.9%)	14 (6%) loss of vitality, 24 (10%) caries, 169 (72%) periodontitis, 118 (50%) gingival recession, 4 (1.6%) endodontic treatments	106	Cracks and fractures: 1 (5%) Max, 23 (21.5%) Man	Occlusal repairs: 23 (22%) Max, 20 (18.5%) Man, 36 (33.9%) metal tarnishings

Max = maxilla; Man = mandible; NR = not reported.

six (26%) patients, minor denture repairs were necessary due to the accidental dropping of the dentures during oral hygiene procedures. It was concluded that nonrigid telescopic connectors with two interforaminal implants for overdenture stabilization are an efficient and effective treatment modality in severely resorbed mandibles.

In a later prospective study by Krennmair et al,[29] the aim was to evaluate the implant survival, periimplant bone changes and prosthodontic maintenance requirements for implant-supported mandibular overdentures retained with an anchor or telescopic crown attachment. During a 3-year follow-up period, 13 patients with anchor attachments on 26 implants were compared to 12 patients with 24 implants supporting telescopic overdentures. No differences were observed in the implant survival, implant mobility, and periimplant bone changes of both retention modalities during the observation period. Implants supporting telescopic dentures were observed with 4 (16.6%) outer telescope activations and 3 (12.5%) inner telescope loosening whereas implants with anchor attachments demonstrated 25 (96%) outer telescopic activations. The most frequent prosthetic complications were overdenture relining and repairs. Nine (75%) relinings and 4 (33.3%) repairs in telescopic reconstructions and 15 (115%) relinings and 4 (30.7%) repairs in the anchor denture group were noted.

Due to the lack of detailed information of the included publications, the calculation of a meta-analysis is not possible. In addition, the studies demonstrate heterogeneous study designs that complicate a direct comparison of the results.

Figures 2 and 3 depict the failure rates for tooth and implant telescopic abutments and dentures, respectively. Telescopic abutments on teeth show a wide range of failure rates. It is striking in all these studies that the failure rates in relation to the time axis increases. The information regarding implant telescopic abutments is limited, with a tendency of reduced failure rates compared with tooth telescopic abutments. Similar results are observed in the field of tooth-supported and implant-supported telescopic dentures; however, the number of included trials is much lower than for telescopic abutments.

Discussion

The prevalence of RPDs among adults in Europe varied between 13% and 29%, with 3% to 13% of edentulous patients wearing complete dentures.[18,21,30] A higher frequency of removable restorations were present in patients with a lower socioeconomic status, in older age groups, and with lower education levels. Among the European countries, the frequency of fixed restorations including crowns and FDPs was the highest in Sweden (45%) and Switzerland (34%). A trend towards the increased use of fixed restorations and a reduction in complete dentures was observed over the last few decades.[31]

RPDs have been associated with poor patient acceptance, compromised function and esthetics, and an increased risk of caries and periodontal disease.[32] FDPs are often preferred by patients due to their advantages of superior esthetics and comfort, but may be contraindicated due to few remaining teeth, abutments with an uncertain prognosis, or the need to reconstruct a large volume of lost hard and soft tissues. In patients preferring a comfortable denture supported by few or compromised

Table 6 Studies with implant-supported telescopic reconstructions

				Implants			Dentures		
Study	No. of patients	Mean age (range) years	Mean observation time (years)	No. of implants	Implant systems	Implant failures (%)	Implant complication (%)	No. of dentures	Denture failures (%)	Denture complications (%)
Eitner et al (2008)[28]	58 with telescopic dentures, 51 with bar attachments	>62.0	3.4 ± 1.8	154 implants with telescopic crowns, 169 implants with bar attachments	Straumann, HaTi, Ankylos, Branemark, TPS.	8 (5.2%) implants with telescopic crowns, 11 (6.5%) implants with bar attachments	Implants with telescopic crowns: 3 (2.1%) had bone loss of 25% to 50%. Implants with bar attachments: 17 (10.4%) had bone loss of 25% to 50%	Telescopic: 58, Bar attachments: 51	NR	NR
Heckmann et al (2004)[5]	23	74.1	10.4	46	Straumann solid screw	1 (2.1%)	1 (2.8%) periimplantitis, 3 (6.3%) gingivitis, 4 (8.6%) recementation of primary copings, 5 (10.8%) occlusal screw loosenings	23	0	5 (21.7%) overdentures relined, 6 (26%) minor overdentures repairs
Krennmair et al (2006)[29]	12 with telescopic dentures, 13 with anchor attachments	63.2	3.0	24 implants with telescopic crowns, 26 implants with anchor attachments	Camlog Implants	0	Implants with telescopic crowns: 4 (16.6%) outer telescopic activations, 3 (12.5%) inner telescope loosening. Implants with anchor attachments: 25 (96%) outer telescopic activations	Telescopic: 12, Anchor: 13	0	Telescopic dentures: 9 (75%) relinings, 4 (33.3%) repairs. Anchor dentures: 15 (115%) relinings, 4 (30.7%) repairs

NR = not reported.

abutment teeth, the telescopic concept may be used to satisfy the patients' demands and expectations.

In the present review, the mean survival rates for telescopic abutment teeth ranged from 82.5% (3.4-year follow-up[18]) to 96.2% (6 years follow-up[21]). Abutment tooth loss was attributed mainly to progression of periodontal disease, secondary caries, and tooth fractures. A higher incidence of tooth loss in the maxilla than in the mandible was reported in only one article.[27] These observations were, however, not confirmed in a study by Wagner and Kern[16] in which maxillary and mandibular telescopic reconstructions were compared.

The major biological complications affecting the tooth abutments were gingival inflammation, periodontal disease, and caries. Frequently reported technical complications were the loss of retention of the primary double crowns and loss of facings of the outer frameworks. In some of the cohorts, higher incidences of loss of cementation (37%, 7.4-year follow-up[14]), secondary caries (26.9%, 6.1 to 7.8-year follow-up[22]), and facing repairs (26.9%, 5.3 $\pm$ 2.9-year follow-up[15]) were documented. This has to be related to the estimated 10-year risk for the loss of an FDP due to caries (2.6%) and periodontitis (0.7%). Additionally, the 10-year risk for loss of retention was indicated with 6.4%, and 2.1% for abutment fracture.[10]

The survival rates of the telescopic dentures ranged from 66.7% (follow-up of 10 years[16]) to 98.6% (follow-up of up to 6 years[21]). The main reasons for the denture failures were the loss of abutment teeth and denture fractures.[18,19] In one of the included papers, the majority of failures occurred in the first 2 years postinsertion.[18,33] Full-mouth reconstructions supported by fewer than three abutment teeth were less favorable in the distribution of loading forces and had a significantly reduced survival probability.[15,33] The reconstructions in the included studies were supported by both teeth and mucosal tissues, especially in distal extension situations. The heterogeneity in the design of the dentures precluded any further comparisons.

The ranges of survival rates with telescopic prostheses found in the present review must be related to the outcomes obtained with other types of prostheses. At 5 years, the mean estimated cumulative survival rates (CSRs) are: 92.3% for FPDs with end abutments,[10] 95% for implant-supported FDPs,[9] 94.3% for cantilever extension FDPs on implants,[11] 94.1% for tooth-implant-supported FDPs,[8] and 96.4% for cross-arch FDPs on periodontally compromised teeth.[6] At 10 years, the mean estimated CSRs for these types of reconstructions ranged from 77.7% to 92.9%. For RPDs, the mean estimated survival rates at 5 years were 75%, and 50% at 10 years.[7]

In the three papers included in the present report, there were no overdenture failures observed with telescopic implant-supported abutments placed in the mandibular anterior region. The survival rates of mandibular overdentures supported by two implants demonstrated high survival rates. Greater concern is, however, expressed when it comes to the required prosthetic maintenance procedures.[34] This has a considerable impact on the long-term economic prospects. Nine (75%) relinings and 4 (33.3%) repairs over a 3-year period of 12 dentures,[29] and 5 (21.7%) relinings and 6 (26%) repairs in a 10-year follow-up of 23 dentures[5] demonstrate the need for intensive prosthetic maintenance. It is, however, not known why in some cohorts almost all dentures[22] needed relining/rebasing procedures whereas in other cohorts the frequency was relatively low.[15] Telescopic dentures required a higher rate of maintenance service than conventional RPDs.[35]

Implant loss was not evident, and biological as well as technical complications were rarely observed. Screw loosening and recementations of the primary abutment crowns were the main mechanical complications of the implant-supported telescopic reconstructions.

In summary, the abutments of tooth-supported telescopic reconstructions show a wide range of survival rates, whereas the dentures demonstrate better results. This fact can be explained by different telescopic treatment concepts. Telescopic supported dentures are composed of either two selected teeth of the remaining dentition or all remaining teeth of the arch. When evaluating the clinical survival rates, the telescopic abutment selection is very important for the long-term success of the entire restoration. On the one hand, the loss of one abutment will result in a loss of the complete restoration when the telescopic denture is supported by only two double crown abutments. On the other hand, it is easy to compensate for abutment loss when telescopic abutments are fabricated for all remaining teeth because this concept enables an easy modification while maintaining the function of the restoration.

One major advantage of the double crown therapy concept is that especially in cases with a reduced number and unfavorable distribution of prosthetic anchor teeth, telescopic RDPs provide an alternative treatment opportunity to rehabilitate patients without additional surgical interventions, as for example, the placement of implants. Implant-supported telescopic overdentures are an adequate alternative to the conventional implant attachment components (e.g., bars or ball attachments). Major aspects for a long-term stable treatment success are the number and the strategic distribution of the telescopic double crown abutments as well as the involvement of the patients in the follow-up maintenance care program.

The lack of information on abutment and denture exposure times, nonstandardized definitions of complications and failures, several reconstruction designs, and the wide range of survival rates precluded pooling of the data (rates of events per 100 reconstructions per year). Future areas of research would involve the designing of appropriate longitudinal studies with clearly defined parameters for the comparison of survival and complication rates of different reconstruction designs to achieve a higher level of scientific evidence.

For this review, failure and complication rates per 100 dentures/abutments per year could not be calculated due to the lack of detailed information in the original publications. Nevertheless, the retrieved data clearly indicate that in some of the patients' cohorts/cases, rather unsatisfying results had been noted, whereas in other cohorts, comparable survival rates of the telescopic abutments were achieved. This fact can be explained by the unforgiving technical demands and the precision as well as the increased risk for biofilm accumulation around the hidden telescopic crowns. It was also striking to note that in some of the publications no exact maintenance protocol was described.

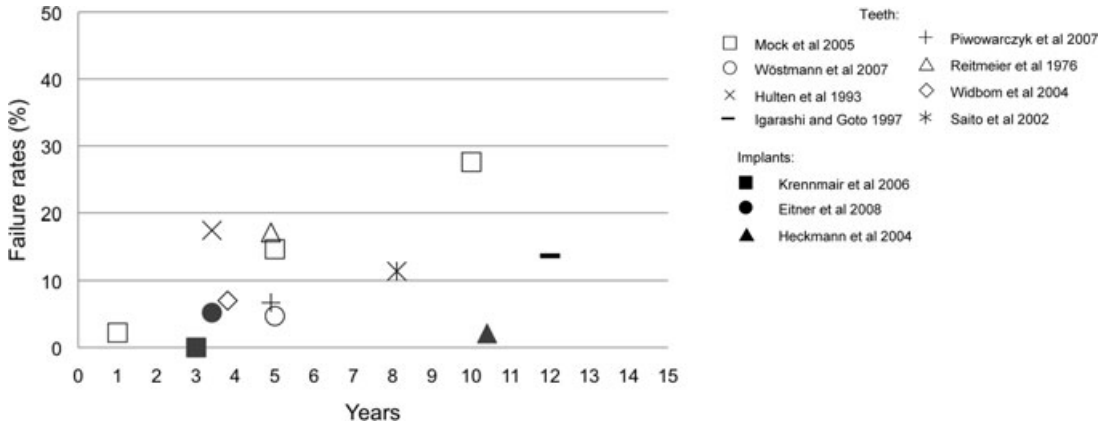

Figure 2 Failure rates of tooth and implant telescopic abutments.

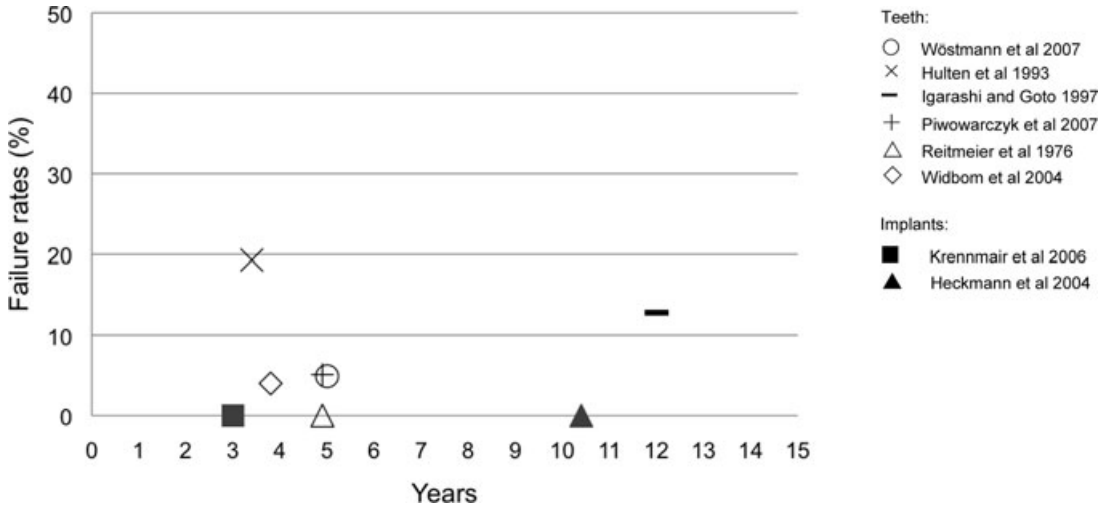

Figure 3 Failure rates of tooth-supported and implant-supported telescopic dentures.

Conclusions

The main findings of this review are:

(1) The included studies demonstrated a wide range of survival rates affecting the double crown tooth abutments. The main reasons for tooth loss were the progression of periodontitis, secondary caries, and fractures of the abutment teeth.
(2) The major biological complications affecting the tooth abutments were gingival inflammation, periodontal disease, and caries. The most frequent technical complications were the loss of cementation of the primary double crowns and the loss of facings of the outer frameworks.
(3) The studies reported higher survival rates for tooth-supported double crown prostheses compared to those of tooth-supported double crown abutments. Loss of abutment teeth and denture fractures were the major causes for failures.
(4) The main technical complications for dentate double crown prostheses were the high incidences of denture relining and rebasing. Three or more tooth-supported RDPs showed significantly lower failure rates than reconstructions with one or two double crown abutments.
(5) Implants supporting telescopic prostheses demonstrated higher survival rates compared with tooth-retained double crown RDPs; however, the included number of studies was limited.
(6) The implant-supported mandibular overdentures demonstrated a more favorable long-term prognosis compared to reconstructions on teeth.
(7) Extensive prosthetic maintenance procedures are required for both the tooth and implant-supported double crown reconstructions.
(8) Future areas of research would involve designing appropriate longitudinal studies with clearly defined parameters for comparisons of survival and complication rates of different reconstruction designs.

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