Telescopic Crowns on Implants and Teeth: Evaluation of a Clinical Study After 8 to 12 Years

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Purpose: *To evaluate the outcome of a clinical study on telescopic-crown–retained removable dental prostheses (TCR-RDPs) on implants or implants and teeth after 8 to 12 years.* ***Materials and Methods:*** *Between 1999 and 2002, 39 (41 arches) patients received implant- or combined tooth-implant–supported TCR-RDPs in the maxilla and/or mandible. One-stage surgery was performed, and after a conventional healing period, TCR-RDPs were inserted. Thirty-one patients (33 prostheses) were available for annual follow-up investigations with a standardized protocol from 2010 until 2013. Cumulative survival and success of the abutments were estimated using the Kaplan-Meier method, and a Cox regression model was used to identify potential predictors for abutment complications. Patients' oral health–related quality of life (OHRQoL) was measured by means of the Oral Health Impact Profile (OHIP).* ***Results:*** *After a mean observation period of 11.3 ± 1.1 years, all restorations were still functioning successfully. Two implants and 10 abutment teeth were lost, leading to significantly different implant and tooth survival rates of 97.6% (SE ± 1.7%) and 81.8% (SE 5.3%; P = .007). Implants placed in the mandible and those in the group with a higher number of abutments (five to six vs two to four) showed higher success rates. The success rates of abutment teeth were not influenced by location (mandible vs maxilla) or number of abutments (five to six vs two to four).* ***Conclusion:*** *Implant- or combined tooth-implant–supported TCR-RDPs provided a satisfying treatment option for patients with severely reduced dentition in the long term. Due to the small sample size, the results presented should be interpreted with caution.* Int J Oral Maxillofac Implants 2019;34:977–986. doi: 10.11607/jomi.7204

Keywords: *complication, double crown, implant-retained prosthesis, removable dental prosthesis, survival rate, telescopic crown*

A reduced dentition can be restored by means of various prosthodontic options. In this context, implant-supported reconstructions can be considered a well-established treatment method for different indications, and several long-term studies have demonstrated high implant survival rates.[1–3]

Prosthodontic rehabilitation with double-crown–retained prostheses on natural abutments is a frequently used method that has often been described and investigated by different authors.[4–9] However, technical and biologic complications were not uncommon. Behr et al[4] described rates of 48.8% and 34.2% of technical complications occurring in conical-crown or telescopic-crown–retained prostheses, respectively, on natural abutments within an evaluation period of 6 years. The other cited authors also observed technical shortcomings such as retention loss, acrylic fractures, lost or discolored facings, and wear; and biologic complications such as tooth fractures, pulpitis, caries, and development of periodontal pockets.

Studies reporting only on implant-retained/-supported removable dental prostheses (RDPs) with double crowns are rare,[9,10] but very promising short-term results with an implant survival of 99% to 100% and comparatively few technical complications have been reported.[11–14]

The symmetric bilateral distribution of abutment teeth seems to positively influence the tooth loss rate.[15] Hence, the insertion of dental implants in strategically advantageous positions is suggested to achieve quadrangular prosthetic support that could presumably

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strengthen the prognosis of natural abutment teeth and contribute to the stability of the reconstruction.[16] The number of abutments also seems to be decisive for the probability of telescopic-crown–retained RDP (TCR-RDP) survival,[17] and for this reason, it might be advisable to increase the number of only a few residual teeth with dental implants.

The data concerning the situation for combined tooth- and implant-supported telescopic RDPs have improved to some extent over the last few years, demonstrating favorable outcomes[18–22]; nonetheless, there is still a huge backlog of demand for high-quality clinical studies.

The number of abutments that would be necessary to achieve a satisfactory outcome regarding stability, longevity, and maintenance of a double-crown–retained prosthesis is, however, still unclear. Furthermore, to the best of the authors' knowledge, the question of whether the prosthesis design (solely abutment-supported or mucosa-borne as well) has an impact on implant or tooth survival or success has not yet been investigated.

Therefore, the aim of this analysis of a prospective clinical cohort study was to evaluate *(1)* the survival rates of implants and abutment teeth, and *(2)* the success rates of implants and abutment teeth of solely implant-supported and combined implant-tooth–supported TCR-RDPs, depending on the prosthesis location and different numbers of abutments. It was hypothesized that prosthesis location and number of abutments would have no influence on the survival and success rates of implants and abutment teeth. Furthermore, the occurrence of technical and biologic complications and patients' oral health–related quality of life (OHRQoL) were investigated.

MATERIALS AND METHODS

Trial Design

The study was originally designed as a prospective, observational clinical trial and was approved by the Ethics Committee (EK No. 890) of the Medical Faculty of RWTH Aachen University. After baseline, follow-up investigations were conducted only within the scope of regular after-treatments or if patients had problems. A planned and standardized recall period of 4 years took place between 2010 and 2013, and patients were examined once a year during this period.

Patients

Between July 1999 and November 2002, patients were consecutively recruited at the Department of Prosthodontics and Biomaterials, Medical Faculty, RWTH Aachen University, Germany. Patients were included if they met the following inclusion criteria:

- Severely reduced dentition with a maximum of four residual abutment teeth (one completely edentulous patient was included)
- Vital teeth or teeth with sufficient endodontic treatment, probing depths < 4 mm, no bleeding on probing
- Good general health
- Informed consent given

The exclusion criteria were as follows:

- Need for major bone augmentation procedures (including sinus elevation and block grafting)
- Cranio-mandibular disorders
- Psychologic disorders
- Drug abuse

All treated patients were assigned to one of the following treatment groups:

- TCR-RDPs with two to four abutments
- TCR-RDPs with five to six abutments

Intervention

If necessary, endodontic or periodontal pretreatment was performed. Between one and four implants per arch were inserted in strategically meaningful positions to create a tri- or quadrangular, or at least linear support for the restoration. As major augmentative measures had to be avoided, the anatomical situation, ie, the bone morphology, dictated the final implant position. The treatments were performed by eight experienced clinicians.

Implant Treatment

Patients received presurgical administration of antibiotics (Isocillin 1.2 Mega) the evening before surgery and a singular dose of ibuprofen 800 mg 1 hour before implant insertion.

Length and diameter of the implants were chosen depending on bone width and height. A one-stage surgical procedure with a conventional healing period was applied. The implants had a sand-blasted, large-grit, and acid-etched (SLA) surface, an internal connection, and a screw design (Bonefit Dental Implants, Standard design, Straumann). The minimum length of the inserted implants was 10 mm, and the maximum length was 16 mm. The diameters varied from 3.3 to 4.8 mm. Only small, simultaneous bone augmentation was performed (autologous bone chips, bone substitute, collagen membrane), if necessary. Antibiotic administration was continued for 7 days postoperatively. Patients were advised not to wear their prostheses and to avoid hard food until the sutures had been removed (usually after 10 days). During the

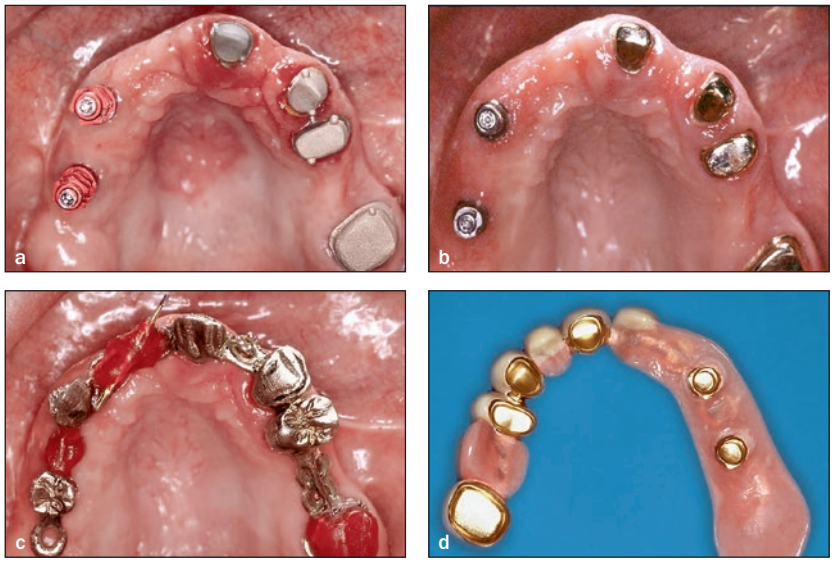


Fig 1 Clinical example from the patient group with five to six abutments: *(a)* implants with impression posts and natural abutments with primary crowns for the fixation impression; *(b)* implant abutments served as primary crowns, natural abutments received primary crowns made of gold alloy; *(c)* fitting of framework (intraoral splinting between implants and natural abutments for a second fixation impression); *(d)* definitive prosthesis.

unloaded healing period, patients either wore newly fabricated provisional prostheses or their existing prostheses were modified and/or relined with a soft silicone material.

Prosthodontic Treatment

After a healing period of 3 to 6 months, the abutment teeth were prepared with a pronounced chamfer, and a circumferential and occlusal reduction of 1.5 to 2 mm. A first precision impression was taken with an individual impression tray and a polyether material (Permadyne, 3M ESPE) to fabricate the inner coping for the abutment teeth from a gold alloy (Wegold M, Wegold Edelmetalle; Fig 1a). After the successful try-in of the inner copings, a combined fixation and implant impression was taken with an individual impression tray and the pick-up technique, using another polyether impression material (Impregum, 3M ESPE). The intra-arch relationship was provisionally registered. The master-cast was fabricated, and implant milling cylinders (titanium, Straumann) were attached to the synOcta (Straumann) implant abutments and retained with occlusal screws. Milling cylinders and synOcta abutments were milled with a 0-degree angle design and served as primary crowns (Fig 1b). The definitive maxillo-mandibular relationship was registered using implant-tooth–supported bite plates. Next, secondary telescopic crowns were manufactured from a gold alloy (Wegold M, Wegold Edelmetalle), and the framework from cobalt-chromium-molybdenum. To achieve a stress-free fit, the secondary reconstruction was tried in in separate pieces, and then blocked with acrylic resin (Pattern Resin LS, GC) intraorally (Fig 1c). The intra-arch relationship was again registered with the secondary reconstruction, and a fixation impression was taken with Impregum.

After a successful try-in of an individual wax-up/set-up, the TCR-RDPs were finalized and incorporated. Whenever possible, maxillary prostheses did not have a palatal connector (Fig 1d). The prosthesis design enabled adequate periodontal hygiene to be performed. The primary crowns on the abutment teeth were cemented with Harvard cement (Richter & Hoffmann Harvard Dental). The synOcta abutments were inserted with 30-Ncm torque and the occlusal screws of the milling cylinders with 15 Ncm. All prostheses were set up in a harmonious occlusal relationship. Occlusal adjustments were made if necessary.

Figures 1a to 1d show a clinical example of the patient group with five to six abutments.

Follow-up Investigations

A baseline examination was performed after prosthesis insertion and comprised the parameters mentioned below. Patients were not examined in accordance with a standardized protocol after baseline until 2010.

From 2010 until 2013, patients were examined annually. Every follow-up investigation was carried out by one examiner, included the medical history record and an extra- and intraoral examination, and was in accordance with the following parameters:

- Plaque Index (PI)[23]
- Sulcus Bleeding Index (SBI)[24]
- Probing depth (mesial, distal, buccal, lingual) with a Hu-Friedy PCP11.5B probe (Hu-Friedy)
- Biologic and technical complications according to severity of follow-up treatment (based on Wolfart et al[25] and Studer et al[26])

Biologic:

- Minimal treatments: pressure sores (treatment of denture sores), parafunction (occlusal adjustments)

- Moderate treatments: caries (filling treatment), pulpitis (endodontic treatment), periodontitis (root planning/periodontitis therapy), peri-implantitis (peri-implantitis therapy; if necessary, radiographic images were taken and compared with baseline images to assess the degree of bone loss)
- Extensive treatments: tooth loss (extraction), implant loss (explantation)

According to Lang and Berglundh,[27] peri-implantitis was "characterized by changes of the level of crestal bone, presence of bleeding on probing and/or suppuration; with or without concomitant deepening of peri-implant pockets." Peri-implant mucositis was defined as being "associated with bleeding on gentle probing, but the inflammation resides in the mucosa."[27]

Technical:

- Minimal treatment: relining, loosening/loss of abutment screw (retightening/new screw)
- Moderate treatment: decementation of primary crown (recementation), fracture of connector (repair), fracture of facing/acrylic saddle (renewal/repair), loss/wear of acrylic tooth (renewal)
- Extensive treatment: fracture of post (remake of post and core), framework fracture (remake)

Moreover, patients were asked to fill in a questionnaire concerning the OHRQoL. The OHRQoL was measured by means of the Oral Health Impact Profile (OHIP).[28,29] The long version of the OHIP consists of a 49-item questionnaire. It covers the following items: functional limitation, physical pain, psychic discomfort, psychic disability, physical disability, social disability, and discrimination/handicap. The questions have to be answered by a five-point Likert Scale: 0 = never, 1 = hardly ever, 2 = occasionally, 3 = quite often, and 4 = very often. The sum score of all 49 items indicates a patient's present status concerning the OHRQoL. This sum score ranges from 0 (very good OHRQoL) to 196 (very poor OHRQoL).

Outcomes

The primary outcome was the evaluation of survival and success rates of implants and abutment teeth. Implant and abutment tooth success was assumed to be independent of the location (mandible vs maxilla) or number of abutments (five to six vs two to four) used to support the prosthesis. An abutment still being in situ, irrespective of its condition, was defined as "survival." To evaluate the "success rate," the first moderate to severe biologic complication of an abutment that occurred (periodontitis/peri-implantitis, endodontic treatment, loss of tooth or implant) was included in the analysis. Secondary outcomes included evaluation of biologic and technical complications, and an analysis of maintenance requirements. Furthermore, OHIP-49 questionnaires were analyzed to reveal the patients' OHRQoL.

Statistical Methods

A descriptive analysis including means and standard deviations of the parameters analyzed was performed. Cumulative survival and success rates of implants and teeth were estimated using the Kaplan-Meier method, and comparative analysis between the subgroups was conducted by means of a log-rank test at a 95% confidence level. Analyses were undertaken at the implant and tooth levels. A multiple Cox regression model was used to evaluate the effect of different potential risk factors for moderate to severe abutment complications.

If the time of tooth or implant loss was before 2010, the necessary information was taken from the patient's file and/or obtained by means of personal communication with the patient.

The median OHIP sum scores were calculated and compared in an intergroup analysis by means of the Kruskal-Wallis test. Additionally, the Pearson correlation coefficient between the OHRQoL and the number of abutments was calculated.

The IBM SPSS statistics, version 21 program (IBM, Armonk) was used for the statistical analysis.

RESULTS

Patient Flow

In 2002, 39 patients received 41 prostheses. One patient was included, although he was completely edentulous. He had lost his last natural abutment tooth after implant insertion. All of the patients initially included in the study completed the baseline examination. Between 2010 and 2013, 31 patients, including two patients with two prostheses each (mean age 56.7 ± 8.5 years), with a total of 66 natural abutment teeth (mean/patient: 2.0 ± 1.3; range: 0 to 5) and 84 implants (mean/patient: 2.6 ± 0.9; range: 1 to 4) were examined. The mean observation period was 11.3 ± 1.1 (range: 8.8 to 13.0) years. Three patients had died, and five patients were unavailable, did not wish to take part, or moved away (dropouts: n = 8). Two patients received TCR-RDPs in the maxilla and mandible, resulting in group sizes of 17 and 16, respectively. Seventeen patients were female (51.5%). Table 1 provides an overview of implant and abutment tooth locations.

Abutment Survival

Altogether, 2 implants and 10 abutment teeth were lost. Both implants were lost in the same patient in the maxilla (group with two to four abutments) after 3.75 and 9.16 years as a result of severe peri-implantitis.

Table 1 Locations of Implants and Natural Abutment Teeth in 31 Patients with 33 Prostheses

Group no./ Prosthesis no.	FDI tooth no.																Totals		
	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	I	A	Ab
1																			
4	–	X	X	X	ITC	ITC	X	RT	RT	RT	ATC	X	X	RT	–	–	2	1	3
5	–	–	X	X	ITC	ITC	X	X	X	X	ATCL[a]	ITC	X	X	–	–	3	1	4
10	–	–	ATC	X	X	ITCL[a]	X	X	X	X	ITCL[a]	X	X	X	ATC	–	2	2	4
19	–	X	ITC	X	X	X	ITC	X	X	ITC	X	X	ITC	X	X	–	4	0	4
29	–	X	X	X	ITC	ITC	X	X	ATCL[a]	X	ATCL[a]	X	X	X	X	–	2	2	4
31	–	X	ATCL[a]	X	X	ITC	X	X	X	X	ITC	X	X	ITC	–	–	3	1	4
33	–	–	X	X	ITC	ITC	RT	RT	RT	RT	ITC	ITC	X	X	–	–	4	0	4
2																			
6	–	ATC	X	X	X	X	ATC	ATC	ATC	X	ITC	X	X	ITC	X	–	2	4	6
11	ATC	X	X	X	ATC	ATC	X	X	X	ITC	X	X	ITC	X	X	ATC	2	4	6
12	–	RT	–	ITC	X	X	ITC	X	X	ITC	X	ATC	ATC	RT	–	–	3	2	5
18	–	ITC	ITC	X	X	ITC	X	X	X	X	ATC	X	X	ATCL[a]	–	–	3	2	5
25	RT	–	ATC	–	X	ATC	ATC	X	X	ATCL[a]	ATC	X	X	X	ITC	–	1	5	6
26	–	ATC	ATC	X	X	ITC	X	X	X	X	ITC	X	X	X	ATC	–	2	3	5
34	–	–	X	ITC	X	ITC	X	X	ATC	X	ATC	ATC	X	–	ATC	–	2	4	6
	FDI tooth no.																		
	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38			
1																			
2	–	–	ITC	X	X	ATC	X	X	X	X	ATC	X	X	ITC	–	–	2	2	4
3	X	ATC	X	X	X	ATC	X	X	X	X	ITC	X	X	ITC	–	–	2	2	4
8	–	ITC	X	X	ATC	RT	RT	RT	RT	RT	ITC	X	X	ITC	–	–	3	1	4
13	–	–	ITC	X	X	ITC	X	X	X	X	ATC	X	X	ITC	–	–	3	1	4
15	–	X	X	X	ATCL[a]	RT	RT	RT	RT	RT	ITC	ITC	X	X	X	–	2	1	3
16	–	ITC	X	X	X	ITC	RT	RT	RT	RT	ITC	X	X	X	ITC	–	4	0	4
20	–	X	X	X	ATC	ATC	RT	RT	RT	RT	ITC	ITC	X	X	–	–	2	2	4
23	–	ITC	X	X	RT	RT	RT	RT	RT	RT	ITC	X	X	ITC	–	–	3	0	3
24	–	–	ITC	X	X	ATC	X	X	X	X	ATC	X	X	ATC	–	–	1	3	4
30	–	X	X	X	X	ITC	RT	RT	RT	RT	ATC	X	X	X	X	–	1	1	2
2																			
1	–	–	ATC	X	X	ITC	X	X	X	X	ITC	X	ATC	ITC	X	X	3	2	5
9	–	ITC	X	X	ATC	ITC	X	X	X	X	ITC	X	X	X	ITC	–	4	1	5
14	–	X	ITC	X	X	ATC	X	X	X	X	ATC	ATC	X	ITC	X	–	2	3	5
17	–	ITC	X	ATC	X	ITC	X	X	X	X	X	ATC	ATC	X	ATC	–	2	4	6
21	–	–	ITC	X	ITC	X	X	X	X	ITC	X	ATC	ATC	X	ITC	–	4	2	6
22	–	–	ITC	X	X	ITC	X	X	X	X	ITC	X	ATCL[a]	ATCL[a]	–	–	3	2	5
27	–	ITC	X	ATC	X	ATC	X	X	X	X	ITC	X	X	ITC	–	–	3	2	5
28	–	ITC	X	ITC	X	ATC	X	X	X	X	ATC	X	ATC	X	ITC	–	3	3	6
32	–	X	X	X	ITC	ITC	X	X	X	ATC	ATC	ATCL[a]	X	X	X	–	2	3	5
Totals																	84	66	150

I = implant; A = natural tooth abutment; RT = residual tooth; TC = telescopic crown; X = pontic; Ab = total abutments; L = lost. [a]Lost abutments.
1 = 2–4 abutments; 2 = 5–6 abutments.

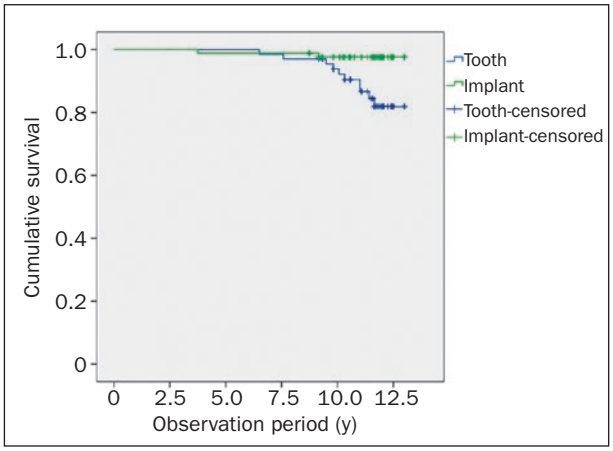
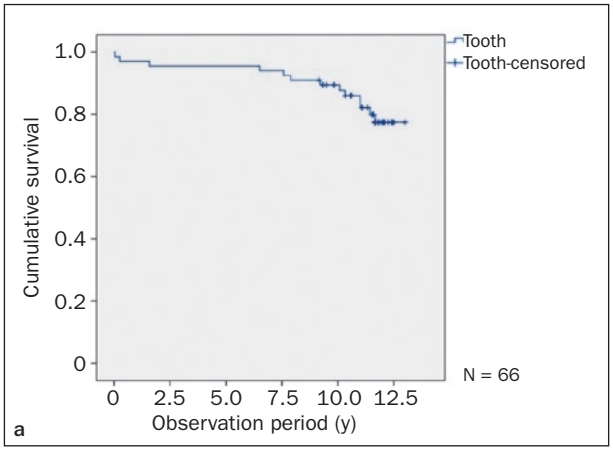


Fig 2 *(Left)* Probability of abutment survival (implants and teeth).



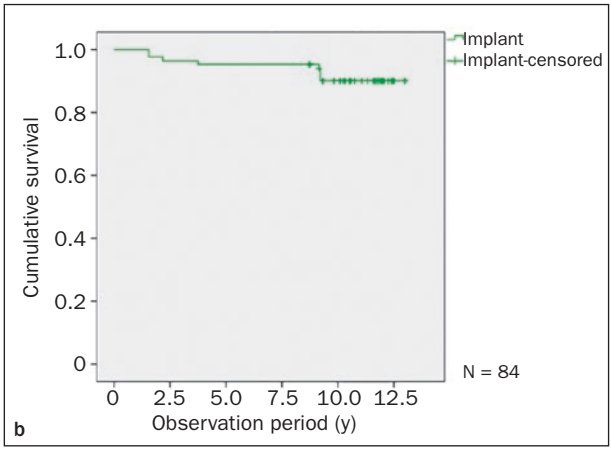


Fig 3 *(Below)* Probability of *(a)* tooth and *(b)* implant success.

Five (four in the maxilla, one in the mandible) abutment teeth were lost in the group with two to four abutments, and in the group with five to six abutments (two in the maxilla and three in the mandible) (Table 1). The overall cumulative survival rate was 97.6% (standard error [SE] ± 1.7%) for the implants and 81.8% (SE ± 5.3%) for the abutment teeth (Fig 2). These survival rates differed significantly ($P = .007$).

No significant difference in tooth survival could be demonstrated when mandibular and maxillary teeth were compared (86.6% [SE ± 6.3%] vs 76.6% [SE ± 8.9%], $P = .242$).

Abutment Success

Altogether, 21 (implants, n = 8; teeth, n = 13) moderate to severe biologic complications occurring first could be identified, leading to success rates of 90.0% (SE ± 3.4%) for implants and 77.4% (SE ± 5.7%) for teeth (Figs 3a and 3b). Due to different criteria for establishing the success of implants and teeth, no comparison was made concerning a potential significant difference between these success rates. Figures 4 and 5 show the probability of implant and tooth success related to location (mandible/maxilla) and number of abutments (five to six/two to four abutments). Implants in the mandible presented fewer complications than those in the maxilla (95.8% [SE ± 2.9%] vs 81.7% [SE ± 6.8%]); $P = .038$). When comparing the success rates of abutment teeth in the mandible with those in the maxilla, no statistically significant difference could be observed (81.1% [SE ± 7.0%] vs 73.2% [SE ± 9.3%]; $P = .379$). When the groups with different numbers of abutments (five to six vs two to four) were compared, the cumulative implant success rates differed significantly ($P = .022$). Here, a higher number of abutments resulted in a higher implant success rate (97.5% [SE ± 2.5%] vs 82.5% [SE ± 6.1%]). The success rates of abutment teeth were not significantly influenced by the number of abutments (5 to 6 = 79.6% [SE ± 6.6%]; 2 to 4 = 72.7% [SE ± 10.7%]; $P = .289$).

The multiple Cox regression model identified a slightly significant influence ($P = .051$) of abutment-mucosa–supported TCR-RDPs on the risk of moderate to severe biologic abutment complications (including implants and teeth) with a corresponding hazard ratio of 3.34 (95% CI: 1.00; 11.19 [Table 2]). The variables age, sex, location, and number of abutments had no effect on the prognosis.

Biologic and Technical Complications Within the Observation Period

All prostheses were still functioning successfully after the observation period. A quantitative analysis of all

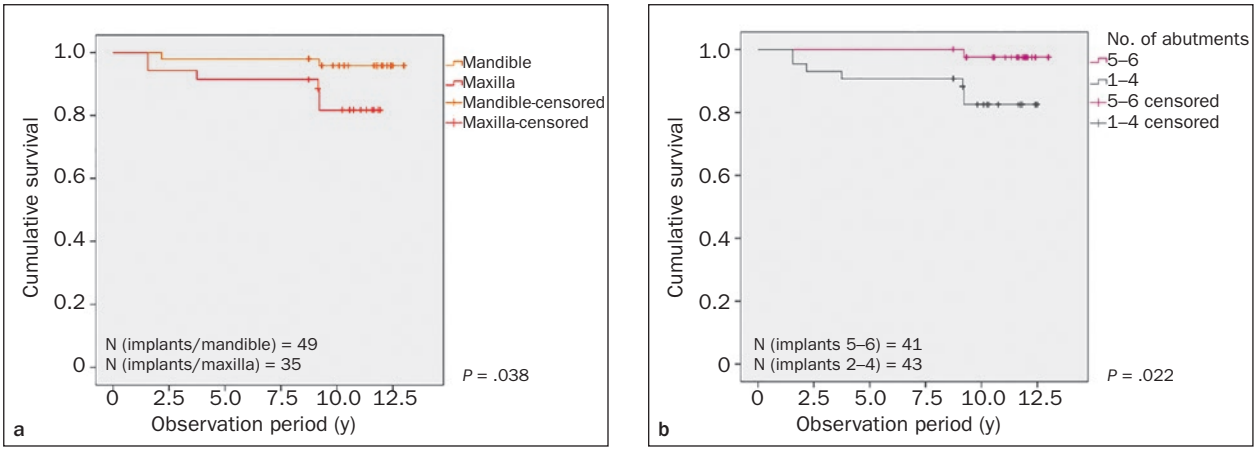


Fig 4 Probability of implant success considering *(a)* location and *(b)* number of abutments.

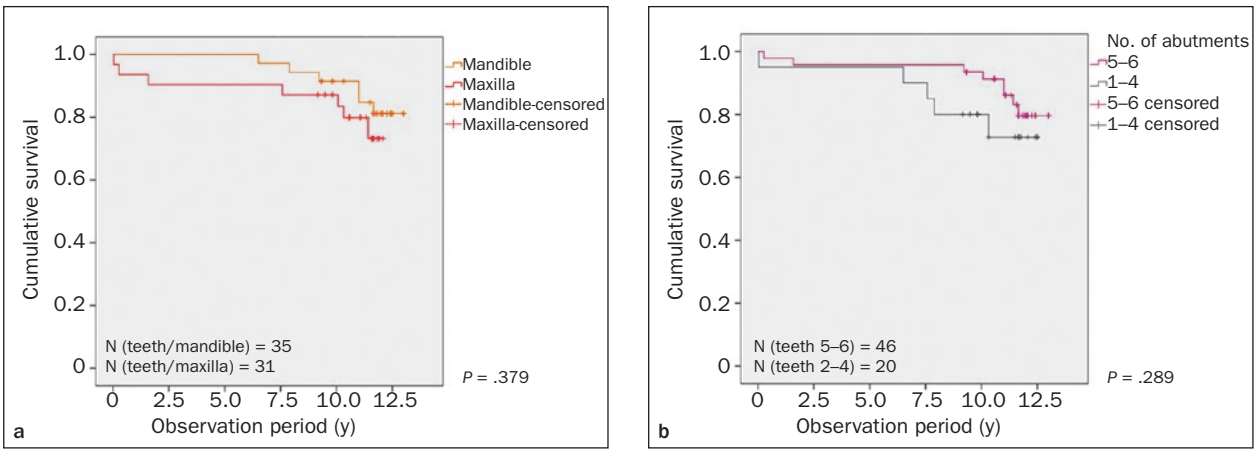


Fig 5 Probability of tooth success considering *(a)* location and *(b)* number of abutments.

Table 2 Effects of Different Characteristics on Risk of Moderate to Severe Biologic Abutment Complications (Including Abutment Losses)

Variable	Level	Abutments	Complication	HR	95% CI	*P*
Age (y)	< 65	66	11	Ref		
	≥ 65	84	12	2.59	0.82 to 8.17	.104
Sex	Female	76	4	Ref		
	Male	74	19	1.30	0.55 to 3.07	.552
Location	Maxilla	64	15	2.07	0.83 to 5.16	.118
	Mandible	86	8	Ref		
No. abutments	2–4 abutments	63	14	1.37	0.43 to 4.32	.592
	5–6 abutments	87	9	Ref		
Support	Only abutment	117	10	Ref		
	Abutment-mucosa	33	13	3.34	1.00 to 11.19	.051

biologic and technical complications from baseline until the end of the evaluation period was carried out. All biologic and technical complications that occurred in all patients were included, summed up, and listed by groups (Table 3). A total of 178 incidents of biologic (N = 58) and technical (N = 120) complications were recorded during the observation period.

In detail, the most frequent biologic complications were caries with 18 events, followed by periodontitis with 13 events, and tooth loss with 10 events. Tech-

Table 3 Events of Biologic and Technical Complications (All Patient Treatments Included)

Severity of treatment	Reason for treatment	Related to[a]	Maxilla		Mandible	
			n	%[b]	n	%[b]
Biologic						
Minimal	Pressure sores	Arch	0	0	1	1.7
	Parafunction	Tooth/implant	0	0	1	1.7
Moderate	Caries	Tooth	10	17.2	8	13.8
	Pulpitis	Tooth	1	1.7	4	6.9
	Periodontitis	Tooth	8	13.8	5	8.6
	Peri-implantitis	Implant	6	10.3	2	3.4
Extensive	Tooth loss	Tooth	6	10.3	4	6.9
	Implant loss	Implant	2	3.4	0	0
	Sum (events per patients)		33	56.9	25	43.1
Technical						
Minimal	Relining	Arch	5	4.1	2	1.6
	Loosening/loss of abutment screw	Implant	0	0	13	10.8
Moderate	Decementation of primary crown	Tooth	3	2.5	6	5.0
	Fracture of connector	Arch	2	1.6	0	0
	Fracture of facing/acrylic saddle	Arch	14	11.6	23	19.2
	Loss/wear of acrylic tooth	Arch	17	14.2	31	25.8
Extensive	Post fracture	Tooth	0	0	1	0.8
	Framework fracture	Arch	0	0	3	2.5
	Sum (events per patient)		41	34.2	79	65.8

[a]Events are related to the type of abutment or to the entire study arch. [b]Percentage of all biologic (58) or technical (120) events occurring.

nical complications were headed by a new set-up of acrylic teeth with 41 events, followed by fracture of facing/acrylic saddle with 37 events, and loosening of abutment screws with 12 events (Table 3).

Furthermore, only the first event occurring in each category of complication per patient was analyzed to establish which complication occurred at least once per patient. Biologic interventions affecting more than 20% of the patients were as follows: tooth loss (22.2%), periodontitis (22.2%), and endodontic complication (22.2%). Technical interventions affecting more than 20% of the patients were as follows: new set-up of acrylic teeth (24.0%), fracture of facing/acrylic saddle (20.0%), and loss of retention of the crown (20.0%).

Periodontal and Plaque Status

The data collected from the latest follow-up investigation showed maximum SBI scores of 0 at 32.0%, 1 at 44.6%, 2 at 21.4%, and 3 at 1.8% of all tooth sites. Of the implant sites, 47.7% had a maximum SBI score of 0; 46.2% had an SBI score of 1; and 6.4% had an SBI score of 2. The maximum PI scores were 0 at 17.9%, 1 at 57.1%, 2 at 14.3%, and 3 at 10.7% of all tooth sites; and 0 at 26.9%, 1 at 55.1%, 2 at 16.7%, and 3 at 1.3% of all implant sites. The mean probing depth was 3.1 ± 0.5 mm (teeth) and 3.2 ± 0.6 mm (implants).

Oral Health–Related Quality of Life

At the latest follow-up, the median OHIP sum scores (25th percentile to 75th percentile) for patients with maxillary prostheses with 2 to 4 abutments were 3 (2 to 6) and 8 (4 to 18.5) for those with 5 to 6 abutments. The median value for patients with mandibular prostheses and 2 to 4 abutments was 14 (9 to 27), and 9 (6 to 28) for those with 5 to 6 abutments. The Kruskal-Wallis test indicated no statistically significant differences between the groups ($P = .087$). Furthermore, the sum score of the OHRQoL did not correlate with the number of abutments ($P = .530$; Pearson correlation).

DISCUSSION

In this analysis of a clinical cohort study, the outcome of TCR-RDPs on implants and teeth was evaluated. The study was originally designed as a prospective clinical study; accordingly, a study protocol was prepared and approved by an ethics committee, and patients gave their informed consent. However, no regular follow-up examinations were performed after baseline, and data were partially taken from the patients' files, which provided the necessary information on the patients' status over the "missing" years. On retracing the records, it was shown that patients visited the clinic within the

scope of regular after-treatments. On the one hand, the missing recalls set a clear limitation to this prospectively planned study, but on the other hand, this fact could even be regarded as an advantage, because this "recall situation" was comparable with that of everyday practice and was, therefore, relatively close to reality.

In total, 2 implants and 10 abutment teeth had to be removed within the mean observation period of 11.3 years. The corresponding survival rates were 97.6% for the implants and 81.8% for the abutment teeth, and hence, were comparable with the survival rates reported by other authors after 8 to 10 years.[30,31] In addition, two systematic reviews[9,32] confirmed these results. The lost implants had to be removed after 3.8 and 9.2 years in one patient with an implant-tooth-mucosa–supported prosthesis, as both implants were affected by severe peri-implantitis.

When the first moderate to severe abutment complication that occurred (including peri-implantitis and implant loss) was included in the analysis, implants in the mandible showed a more favorable outcome compared with implants that were inserted into the maxilla. This fact has not only been reported in another clinical study on combined implant-tooth–supported TCR-RDPs,[21] but also in a meta-analysis evaluating implant survival in edentulous arches,[10] and this outcome might partly be ascribed to the comparatively poor bone structure in the maxilla. However, in the present analysis, the authors were unable to demonstrate differences in tooth success rates between the maxilla and mandible, corroborating the results observed by Wagner and Kern[5] in a comparable retrospective study on removable dental prostheses.

Generally, a higher number of strategically located abutments resulted in higher success rates; however, the implants were only shown to significant benefit when the groups with two to four and five to six abutments were compared ($P = .022$). In the literature, a trend toward higher abutment survival rates with a rising number of abutments could be observed for both teeth and implants.[9,16] Furthermore, in a clinical study on telescopic crowns in severely reduced dentitions (meaning a maximum number of three residual teeth), the authors observed a high number of tooth losses (12 out of 173) after 60 months. Not only a lower number of abutments, but also the unfavorable distribution of abutments were factors increasing the risk for abutment loss in the aforementioned study.[8]

As was expected, in the present study, only-abutment–supported prostheses demonstrated a higher abutment success rate than those that were abutment-mucosa–supported. Further analysis indicated a hazard ratio of 3.34 with regard to abutment complications. The low number of abutments and the free-end saddle design might have been aspects that negatively influenced the abutment outcome. It has to be stated, however, that the "abutment-mucosa" group only included a very low number of patients/abutments, and thus, the analysis should not be over-interpreted.

An increased number of abutments did not lead to significant differences in the patients' OHRQoL. In this context, another interesting approach would have been to make a comparison of the patient's perception of OHRQoL before and after implant insertion; for example, Wolfart et al[33] observed an enhancement of the OHRQoL after strategic implant insertion and subsequent integration of these implants into an existing prosthesis.

Comparatively few biologic and technical complications were detected during the observation period after 8 to 12 years. These complications mainly included secondary caries, acrylic fractures, abraded occlusal surfaces, and the need for retightening abutment screws. The rate of primary crown retention losses in the present study was comparable with that reported by Schwindling et al,[7] who detected 34.2% of decemented primary crowns in a retrospective analysis after 7 years. In general, it could be stated that especially older patients could benefit from TCR-RDPs, because they also provide the opportunity to include abutments with a questionable prognosis; moreover, in comparison with splinted or fixed restorations, for example, oral hygiene could be simplified not only for the patient, but for the nursing staff as well. Once again, the occurrence of complications such as secondary caries and wear of acrylic teeth demonstrated that regular aftercare is mandatory.

The present study was limited by the fact that a low number of patients were observed, and no power analysis was performed prior to the study. Thus, such a small sample size leads to the risk of confounding factors, and consequently, the related univariate Kaplan-Meier analyses have to be interpreted with caution. The dropout rate was 19.5% (n = 8), including five patients who were unwilling to attend the investigation. Of course, these patients could presumably have experienced implant and tooth losses or prosthesis failures, and therefore, a distortion of the present results cannot be ruled out. Although standardization of dental clinical studies is always challenging, the large variance in patient characteristics at the beginning of the study in 2002 constitutes another limitation to the study. Selection criteria such as, for example, distribution of the abutments, number and position of residual teeth (anterior dentition or not), condition of the opposing dentition, or bone quality and quantity could not be considered. Furthermore, four patients with solely implant-supported prostheses were included in the study, and one of them became completely edentulous after recruitment for the study, due to failing pretreatments.

CONCLUSIONS

Always considering the limitations of this study, it could be concluded that TCR-RDPs on implants and teeth revealed a satisfactory outcome. Of the prostheses, 100% were still functioning successfully after 11.3 years. Implants had a higher survival rate than abutment teeth. Furthermore, there was a slight trend toward insertion of implants into the mandible, and inclusion of a higher number of abutments leading to higher implant success rates. It should be noted that the number of patients examined was low, and analyses and conclusions should be assessed accordingly. Due to absence of a patient group without additional strategic implants, the study does not allow any conclusion about whether additional implants would be able to enhance the longevity and success of only-tooth–retained RDPs.

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