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ORIGINAL ARTICLE

Case–control study on the survival of abutment teeth of partially dentate patients

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Abstract
Objectives Due to the scarce amount of data available, a retrospective analysis of patients treated with removable dental prostheses (RDPs) was performed. The aim of the trial was to evaluate the rate of repairs and failures of attachment-retained RDPs (AR-RDPs) compared to clasp-retained RDPs (CR-RDPs) with respect to cofactors (e.g., type of loading). In this respect, two hypotheses were proposed: AR-RDPs are *more prone to repairs* than CR-RDPs, and AR-RDPs are *more prone to fail* than CR-RDPs.
Materials and method Two hundred three patients treated with 135 AR-RDPs and 68 CR-RDPs between 1994 and 2006 were evaluated in this trial. The dental treatment was carried out in the clinical training course of senior students. Kaplan–Meier estimates were calculated for the primary end point (repairs) and for the secondary end point (failures).
Results The survival of CR-RDPs and AR-RDPs did show significant differences regarding repairs (p=0.034) but not with regard to failures (p=0.169). Prostheses of the non-axially loaded group showed no significant differences in the frequency of repairs and failures.
Conclusions Technical complications occurred more frequently in the CR-RDP group. Taking the higher observation time in the AR-RDP group into account, CR-RDPs are more prone to repairs, especially to those with technical background (e.g., fracture of the metal framework).
Clinical relevance The use of crowns with rod attachments on tilted teeth seems to be an appropriate treatment approach in order to simplify removable dental prosthesis design.

Keywords Removable dental prostheses · RDPs · Survival rate · Abutment teeth · Failure · Repair

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Introduction

Removable dental prostheses were frequently used in the treatment of patients with more than six teeth missing in one jaw. There are two major design options for removable dental prostheses (RDP) with cast cobalt–chromium frameworks: attachment-retained (AR-RDPs) and clasp-retained (CR-RDPs). Searching the existing literature, many studies on RDPs were found [1–8]. Nevertheless, studies with high evidence levels investigating different design options, effects, or success rates of RDPs are scarce [9,10]. There is neither a meta-analysis nor a systematic review based on randomized clinical trials. The highest evidence level that could be found was level I based on randomized clinical trials investigating treatment strategies with fixed vs. removable restorations [10–13]. There is only one randomized clinical trial investigating the effectiveness of two partial prosthesis designs [9]. Retrospective designs were commonly used in studies investigating AR-RDPs [1–4,13]. A multitude of various attachment types was used in the trials. Different study conditions (e.g., different practitioners, various types of attachments, different forms of maintenance) make it difficult to compare the studies' results. During the last decade, a new type of

precision attachment utilizing interchangeable plastic matrices gained importance. These rod attachments are to be placed extra-coronally.

Due to the scarce amount of data available, a retrospective analysis of patients treated with RDPs with cast cobalt–chromium frameworks of different designs (AR-RDPs or CR-RDPs) was performed. The aims of our trial were to investigate the survival rate of abutment teeth which were used for AR-RDPs compared to those with CR-RDPs and to gather information about potential reasons for abutment tooth loss.

In this respect, two hypotheses were proposed:

Hypothesis 1: AR-RDPs are *more prone to repairs* than CR-RDPs.

Hypothesis 2: AR-RDPs are *more prone to fail* than CR-RDPs.

Materials and method

The trial represents a retrospective analysis of patients of the Department of Prosthetic Dentistry at the University Hospital of Ulm, Germany, in which patients were treated with RDPs between 1994 and 2006. The dental treatment was carried out during clinical practical courses. The university course in dental medicine in Germany includes a practical clinical training course as part of the curriculum. Senior students who completed their intermediate dental exams are allowed to carry out treatment on their own under the supervision of a qualified dentist.

Participants

Treatment planning was conducted by the former medical director of the Department of Prosthetic Dentistry and a qualified dentist. A dental examination was carried out, and the various treatment alternatives then were discussed with the patient. The patients' suitability for these kinds of restorations was determined, and their willingness to be treated in the students' clinical practical course was requested after decision making. Once a patient consented to be treated in the students' clinical practical course, a cost estimate for treatment in the practical course was prepared with a cost reduction for the dental services. The patients were treated according to the treatment concept of the Prosthodontic Department either with an AR-RDP or a CR-RDP. Preci-Vertix attachments (Alphadent NV, Waregem, Belgium) were used for the AR-RDPs.

Based on the records, all patients who were treated with removable prostheses by students in the 12 years between the summer semester 1994 and the summer semester 2006 were selected. In October 2006, a retrospective evaluation of the patient records was carried out by the investigator (KS). The trial was approved by the ethics committee of Ulm University (vote no. 178/07).

Criteria of evaluation

The data collected from patient records were transferred by the investigator to a case report form (CRF) for each patient. The two-paged CRF consisted of multiple-choice questions. In addition, input fields, e.g., for the date of birth, the date of prosthesis incorporation, and the date of the last checkup or the number of abutment teeth, had to be filled in. The collected variables are listed in Table 1.

Date of birth and gender were recorded as demographic characteristics. Furthermore, prosthesis design and case-specific variables were collected. Three types of RDPs were differentiated: CR-RDPs, AR-RDPs with the above-mentioned rod attachments (Fig. 1), and telescopic crown-retained dental prostheses (TR-RDPs). The age of an already existing removable partial prosthesis was recorded separately for the upper and lower jaws in years. The number of abutment teeth, the tooth numbers according to the FDI World Dental Federation notation of the abutment teeth, as well as the number of replaced teeth were recorded. Either a natural tooth with a clasp or a crowned tooth designed for clasp retention or extra-coronal rod attachment was classified as abutment tooth.

RDPs were classified according to the denture-space categories “free-end,” “tooth-bounded space,” and “combination of free-end and tooth-bounded space.” The position of the load-bearing structure relative to the edentulous space was classified into “saddle close,” “saddle far,” or “combination type.” Tilted abutment teeth were classified as non-axially loaded, and straight abutment teeth as axially loaded. The upper prostheses were divided into two groups: “with palatal plate” and “without palatal plate.” For the lower prostheses, a differentiation was made between “lingual bar connector,” “lingual plate,” and “continuous clasp.”

Biological and technical complications and failures were recorded (Table 1) and classified according to the necessary treatment as non-severe events (repairs) and severe events (Table 2). Repairs were subdivided into biological and technical complications. The extraction of non-abutment teeth with subsequent extension of the prosthesis was rated as biological complication. Technical complications were the repairs of facings, cracks in the denture base, fractures of the denture base, and fractures of the metal framework. Loss of an abutment tooth and the need to redo the removable dental prosthesis were classified as biological or technical failure, respectively.

The numbers of denture relinings and repairs were recorded (“0” to “4”) together with the respective dates.

Table 1 Recorded variables

Demographic variables	Date of birth	
	Gender	
Prosthesis design and case-specific variables	Type of new RDP	CR-RDP
		AR-RDP with Preci-Vertix rod attachments
		Telescopically supported partial prosthesis
	Age of existing RDP	
	Treated jaw	Upper jaw
		Lower jaw
	Number of abutment teeth	
	Tooth numbers of abutment teeth	
	Number of replaced teeth	
	Denture-space categories	Free-end
		Edentulous space
		Combination of free-end and edentulous space
	Type of abutment support	Saddle close
		Saddle far
		Combination type
	Type of loading	Axially
		Non-axially
	Design of upper jaw prostheses	With palatal plate
		Without palatal plate
	Design of lower jaw prostheses	Lingual bar connector
		Lingual plate
		Continuous clasp
	Date of incorporation RDP	
	Date of last checkup	
Biological and technical complications and failures	Denture relining	
	Crack in the denture base	
	Fracture of the denture base	
	Fracture of the metal framework	
	Facing repair	
	Extension	
	Extraction	
	New fabrication	

Denture relinings are generally judged as being part of normal maintenance. The aspects “extension” and “new fabrication of prosthesis” required details on the date of the respective event.

Statistical evaluation

Out of a total number of 329 prostheses made, 203 patients wearing either AR- or CR-RDPs were chosen based on the

Fig. 1 Preci-Vertix rod attachments with plastic matrice (Alphadent NV, Waregem, Belgium)

Table 2 Biological–technical failures and repairs

Repairs (non-severe event)	Biological–technical failure (severe event)
Biological complication	Biological failure
Extraction and extension by one non-abutment tooth	Extraction and extension by one abutment tooth
Technical complication	Technical failure
Repair of a facing	Refabrication
Crack in the denture base	
Fracture of the denture base	
Fracture of metal framework	

identification numbers. Biometric sample size estimation as well as blinding and randomization were not performed due to the retrospective character of the trial. The group with the CR-RDPs served as a control group.

Two groups were defined for the determination of survival rates: "repairs" and "biological–technical failure." The primary end point of an RDP was reached if a non-severe event (repair), as listed in Table 2, occurred. Biological–technical failure was chosen as secondary end point. The survival rate for repairs was calculated using the incorporation date and the date of non-abutment tooth loss/denture repair without relining or the date of the last checkup. The survival rate for the biological–technical failure was calculated using the incorporation date and the date of abutment tooth loss/diagnosis of impossibility of denture repair (implying the inevitability of denture refabrication). If there was no event within the observation time, the incorporation date and the date of the last checkup were used to calculate the survival rate.

In addition to the descriptive statistical analysis, Kaplan–Meier survival rates were calculated (SPSS version 17.0, IBM Corporation, Armonk, NY, USA). Cross tables and bar charts served as graphical presentations.

Results

The patient collective consisted of 104 men and 99 women. On average, patients were 60 years old. Over the observation time period, 329 removable dental prostheses were made in the student courses. Eleven TR-RDPs were excluded due to their low number. Forty-four dental prostheses of patients, who did not take part in the routine checkup examinations, were excluded. Of 71 patients treated with removable dental prostheses in both jaws, only one RDP was randomly chosen for the trial. Out of the total number of 329 prostheses, 203 patients with 135 AR-RDPs and 68 CR-RDPs were evaluated in this trial.

An uneven distribution was found among upper (86) and lower jaws (117). The observation time ranged from 4 up to 141 months. The median observation time was 28 months for CR-RDPs and 49 months for the AR-RDPs (Fig. 2). One hundred nineteen AR-RDPs (81%) and 37 CR-RDPs (57%) were under observation for 24 months or longer.

Space type

Seventy-eight free-end situations and 27 tooth-bounded spaces were restored. A combined restoration of free-end situation and tooth-bounded space was provided 98 times. Free-end situations were treated more frequently with AR-RDPs (58) than with CR-RDPs (20). The tooth-bounded spaces were distributed almost uniformly amongst the CR-RDPs (13) and the AR-RDPs (14). Calculating the distribution of prosthesis types among the space types results in a non-significant difference between CR-RDPs and AR-RDPs regarding the space type (p=0.83) (Fig. 3).

Type of loading

Out of 203 prostheses, the abutment teeth were axially loaded in 179 cases. AR-RDPs and CR-RDPs exhibited a comparably frequent axially aligned abutment distribution (118/87% versus 61/90%). Comparing prostheses with/without an event (repair or failure) with regard to the type of loading (axially/non-axially), RDPs of the non-axially loaded group showed a significantly increased number of repairs (p=0.019) as well as a significantly increased number of failures (p=0.0001).

Repair (non-severe event)

The Kaplan–Meier estimate showed worse survival rates for the CR-RDPs with regard to the first necessary repair. The difference between CR-RDPs and AR-RDPs was statistically

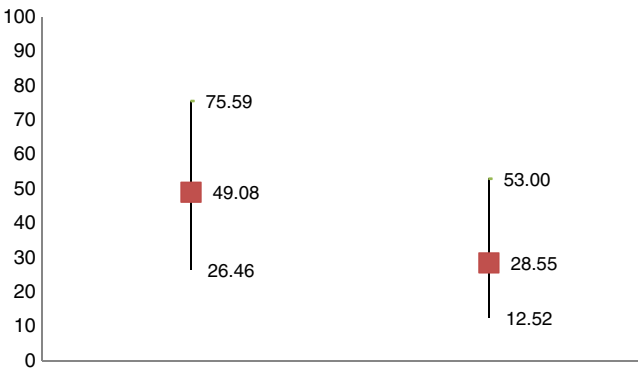

Fig. 2 Median observation time of AR-RDPs (*left*) and CR-RDPs (*right*) in months. *Upper value* 75% percentile, *lower value* 25% percentile

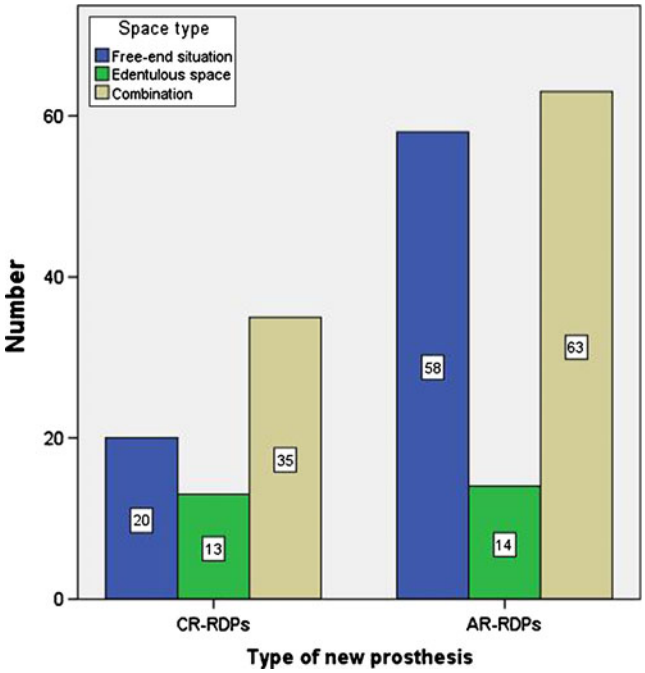

Fig. 3 Space type

significant (p=0.034) regarding the occurrence of the first repair (Fig. 4). In the 203 prostheses evaluated, a total of 37 repairs (18.2%) became necessary during the observation time. Fifteen repairs (22.1%) were performed on CR-RDPs, of which 11 (16.2%) could be allocated to a technical and 4 (5.9%) to a biological failure. Twenty-two repairs (16.3%) were carried out on 135 AR-RDPs, of which 14 (10.4%) were allocated to technical and 8 (5.9%) to biological failures (Table 3).

Biological–technical failure (severe event)

The Kaplan–Meier estimate based on the occurrence of biological–technical failures in the observation time showed no loss of abutment teeth in CR-RDPs (100% survival) and no necessity to redo a prosthesis in this group (Fig. 5) while eight events (seven extractions of and extensions by one abutment tooth each, one refabrication of the RDP) occurred in the AR-RDP group. The first failure event in the group of AR-RDPs took place after 36 months. Most of these events in the AR-RDP group happened after 80 month in service. Due to differences in the mean observation time between the CR-RDP and the AR-RDP groups, only a small number of CR-RDPs were under risk after 60 months. The difference between both groups with regard to failure was not statistically significant (p=0.169).

Discussion

The significance of the trial was limited due to the retrospective design without randomized allocation of treatments. It can be assumed that patients with better compliance were more frequently treated with AR-RDPs. However, randomized allocation of prosthetic treatments with visible clasps vs. invisible attachments might have caused a higher dropout in the CR-RDP group after randomization. Additionally, the inclusion criteria should have been modified to patients willing to accept crowning of the abutment teeth. Taking into account the consistent application of the treatment principles in the clinical training of senior students, the reliable use of the clinical protocol can be assumed. The short observation time in the CR-RDP

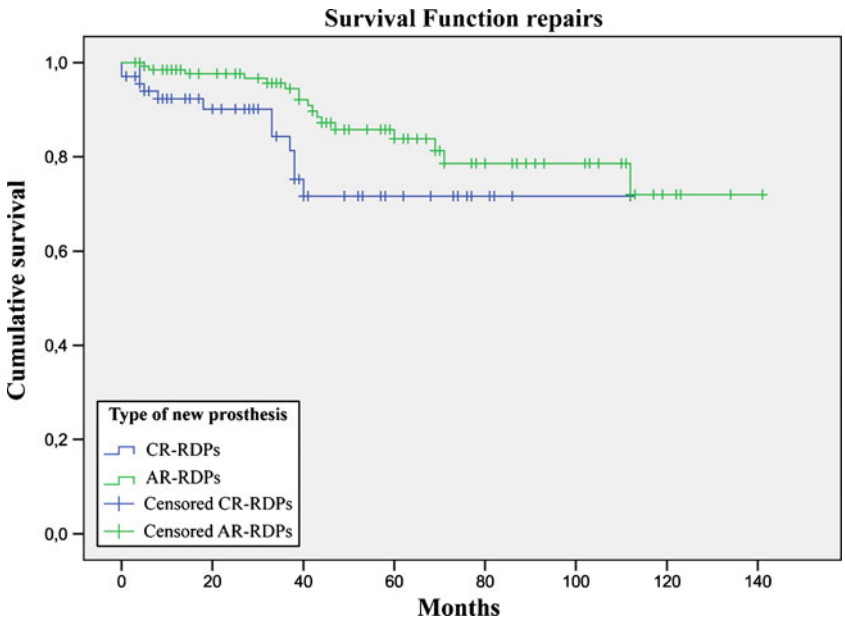

Fig. 4 Kaplan–Meier survival rate for repair susceptibility of CR-RDPs (*blue*) and AR-RDPs (*green*), p=0.034

Table 3 Reason for repairs

Reason for repairs	CR-RDP (n=68)	AR-RDP (n=135)	Total (n=203)
Biological complication Extraction and extension by one non-abutment tooth	4 (5.9%)	8 (5.9%)	12 (5.9%)
Technical complication	11 (16.2%)	14 (10.4%)	25 (12.3%)
Repair of a facing	3 (4.4%)	5 (3.7%)	8 (3.9%)
Crack in the denture base	1 (1.5%)	1 (0.7%)	2 (1.0%)
Fracture of the denture base	2 (2.9%)	5 (3.7%)	7 (3.4%)
Fracture of metal framework	5 (7.4%)	3 (2.2%)	8 (3.9%)
Total	15 (22.1%)	22 (16.3%)	37 (18.2%)

group also limits the significance of the trial. However, this reflects common patients' compliance to treatment and maintenance in the group of partially edentulous patients. Denture relinings are judged as being a part of common maintenance and thus did not represent an event. Therefore, denture relinings are not rated as a repair in the present trial.

Based on the proposed hypothesis that "AR-RDPs are *more prone to repairs* than CR-RDPs," the frequency of repairs (biological and technical) was assessed. The CR-RDPs are more prone to repairs than AR-RDPs due to the significant difference of the Kaplan–Meier estimate. While the frequency of biological complications was 5.9% in both groups, technical complications occurred more frequently in the CR-RDP group. Taking the longer observation time of the AR-RDP group into account, CR-RDPs are more prone to repairs, especially to those with technical background (fracture of the metal framework). According to the laboratory procedure at this time, new clasps were cast and were reassembled using laser welding in order to avoid a refabrication. While Öwall et al. described similar results for necessary repairs on AR-RDPs, Vermeulen et al. found a higher rate of technical complications in AR-RDPs compared to CR-RDPs [1,2]. According to the findings of Vermeulen et al. [2], a fracture of the metal framework was the dominant complication of CR-RDPs. A prospective, randomized trial design (RCT) should be considered for any further trial which can monitor the health benefit of two different therapeutic concepts [12]. A fixed checkup and maintenance system should be established. Attention should be paid to the calibration of all participants by using standardized processes and working procedures. However, discrepancies between the conditions in daily practice and the procedure applied in the RCT [13] might increase which counteracts the idea of practice-based research.

Based on the proposed hypothesis that "AR-RDPs are *more prone to fail* than CR-RDPs," the frequency of losses of abutment teeth and refabrications of the removable dental prostheses was evaluated. The hypothesis that *AR-RDPs are more prone to fail than CR-RDPs* has to be rejected as no

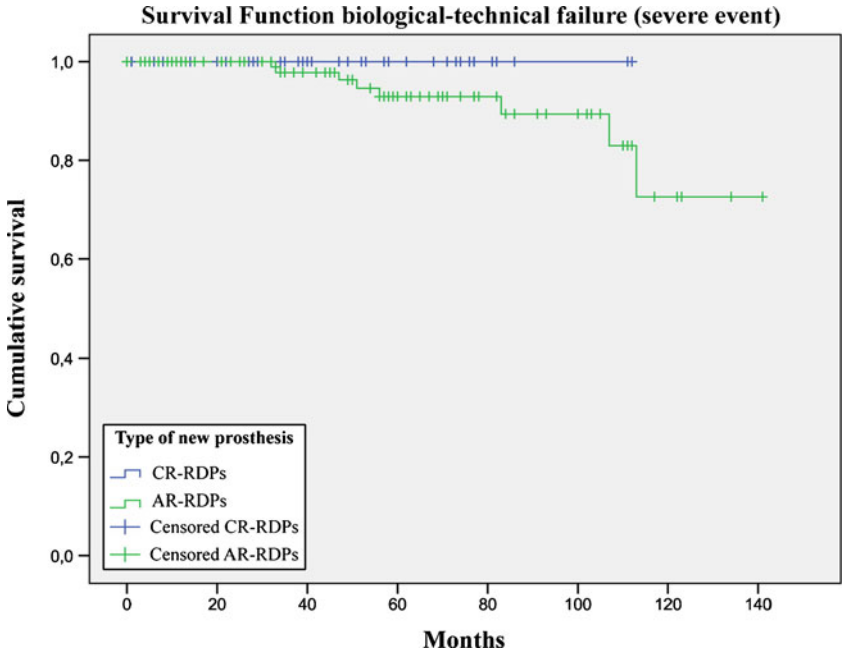

Fig. 5 Kaplan–Meier survival rate showing biological–technical failure (severe event); CR-RDPs (*blue*) and AR-RDPs (*green*), p=0.169

significant difference with regard to failure was found. Looking at the biological–technical failures in the CR-RDP group with a Kaplan–Meier estimator, no failures occurred. Explanations might be the shorter median observation time in the CR-RDP group (28 months) compared to the AR-RDP group (49 months) and the difference in group size (135 AR-RDPs compared to only 68 CR-RDPs). There was no significant difference regarding the frequency of repairs and failures of RDPs concerning axially and non-axially loaded teeth. Placing RDPs in a clinical environment with tilted teeth is a challenging task from the prosthodontist's point of view. The use of crowns with rod attachments on tilted teeth seems to be an appropriate treatment approach in order to simplify removable dental prosthesis design.

Conflict of interest The authors declare that they have no conflict of interest.

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