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ORIGINAL ARTICLE

Clinical success of implant-supported and tooth–implant-supported double crown-retained dentures

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Abstract The objective of this retrospective study was to compare biological and technical complications of implant-supported and tooth–implant-supported double crown-retained dentures (DCRDs) with those of tooth-supported DCRDs. Sixty-three DCRDs were monitored. One study group included 16 prostheses with a combination of implants and natural teeth as double crowns (ti group), whereas in the second study group, 19 dentures were retained exclusively on implants (ii group); a third study group with 28 exclusively tooth-supported dentures served as controls (tt group). Tooth loss, implant failure, and technical complications (loss of retention of primary crown, abutment screw loosening, loss of facing, fracture of resin denture teeth and fracture of saddle resin) were analysed. During the observation period of 24 months, no implants or teeth were lost in the ti group and three technical complications were recorded. In the ii group, two implants were lost, two cases of peri-implantitis occurred and four technical complications were observed. In the tt group, two cases of tooth loss and seven technical complications were observed. At the time of the last examination, all prostheses of the ti group and the ii group were functional. Patients of these two study groups reported high satisfaction with both function and aesthetics with no significant difference between the two groups. Treatment with DCRDs showed comparable results in the three study groups. The 2-year results indicate that double crowns can be recommended for implant and combined tooth–implant-retained dentures.

Keywords Dental implants · Removable partial denture · Survival · Technical complications · Retrospective

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Introduction

In the past two decades, the range of indications for implants has been significantly widened, and most patients seeking treatment with dental implants are now partially dentate. The combination of teeth and implants for the support of fixed partial dentures has been investigated in many studies but remains controversial [1–4]. The use of tooth and implant support for removable prosthetic rehabilitation of partially dentate arch sections is, however, rarely documented in the literature [5–8].

Many elderly patients have much-reduced dentition. Such cases do not enable treatment with fixed prostheses unless an adequate number of implants can be placed, sufficient bone is available, and patients can afford the treatment. Treatment with removable dentures is, therefore, still frequent. The application of double crowns enables the combination of natural teeth and a few implants for the stabilization of a removable partial or full denture [8]. Similar to conventional partial prostheses, implant prosthetics use strategic abutments for prosthetic treatment [9]. Functionally, a favourable support can be achieved with a polygonal abutment arrangement [5].

In the past, the few remaining teeth in highly reduced dentition were often extracted in favour of an implant-retained prosthetic reconstruction. This could be a fixed denture or an overdenture anchored on two to six, or more, implants.

Overdentures in the mandible supported by two implants placed in the interforaminal region have been well documented in clinical investigations and have been suggested as standard treatment for the edentulous patient [10]. The implant-supported removable denture in an edentulous jaw can be attached to a variety of anchors, for example, bars (egg shaped or milled), locators, ball attachments, magnets and double crowns [11–15]. There are few reports of removable dentures in the mandibular and maxillar jaws supported by more than two or four implants and even fewer about combined tooth–implant-supported double crown-retained dentures (DCRDs). Since the use of dental implants for retention of fixed and removable dentures found wide acceptance, failures and complications have been of special concern.

The objective of this retrospective study was to investigate implant and tooth-related failures and the frequency of technical complications of implant-supported (ii group) and tooth–implant-supported (ti group) DCRDs in comparison with a group of tooth-retained DCRDs (tt group).

Materials and methods

This retrospective study was approved by the local university ethics committee. All participants received information about the study and gave their written consent. Data were obtained from the dental-treatment records of the patients of the Prosthodontic Department of the University of Heidelberg.

Patient cohorts and clinical examination

Sixty-three patients (44 males and 19 females) participated in the study. The mean age was 63.3±8.8 years (range, 41–84 years). Some patients had remaining teeth; others were edentulous. All patients received DCRD, either on implants, on both teeth and implants (study groups ii and ti, respectively) or on teeth only (study group tt).

Study groups

Overall, the patients of the ti group and of the ii group received dental implants placed in strategic positions to increase the number of abutments, to achieve a triangular/quadrangular support for a DCRD with galvanoformed secondary crowns in the upper or lower jaw. All implants had internal connections and a screw design of two different implant systems—the Straumann Dental Implant System (Straumann®) and Astra (Astra Tech®). Before implantation, an individual surgical splint was fabricated to assess the implant position.

In one study group, 16 tooth–implant-supported dentures were constructed on 40 implants and 44 abutment teeth (ti group). The mean overall number of abutments was 5.3± 1.34 (range, 4–9). Fourteen of the DCRDs were placed in the maxilla and two in the mandible. Thirteen of the abutment teeth had root canal treatment before prosthetic rehabilitation.

In the second study group, 19 exclusively implant-supported DCRDs were constructed on 84 implants (ii group). The mean overall number of abutments was 4.4± 0.9 (range, 3–6). Twelve of the DCRDs were placed in the maxilla, seven in the mandible.

A third group (tt group) was selected for comparison. The patients of this group received DCRDs anchored exclusively on natural teeth. Twenty-eight patients (21 males and seven females) with an average age of 63± 9.44 years (range, 41–75) received DCRDs with a mean of 3.5±1.32 abutment teeth (range, 2–6). Sixteen of the DCRDs were placed in the maxilla, 12 in the mandible. Thirty of the abutment teeth were root canal filled.

The number, position and distribution of abutments and accordingly the kind of support varied between the study groups. The ti group and the ii group mostly showed polygonal and quadrangular support, respectively, while the tt group showed linear or triangular support most frequently (Table 1).

All patients were treated in accordance with the guidelines of the department by several dentists. The teeth were prepared with a taper of approximately 6°. Impressions were taken using polyether material. Primary crowns were casted with precious alloys and milled with approximately 2°. Secondary crowns were fabricated using a galvanoforming technique. Therefore, the primary crowns got a thin layer of silver lacquer (AGC® Switch conductive silver lacquer, Wieland Dental, Pforzheim, Germany). The gold copings were created by directly electroplating in a fully automated electroplater (AGC® MicroVision, Wieland Dental, Pforzheim, Germany). Electroplating times and currents are selected to produce layers of approximately 0.25 mm in thickness. After removing the electroplated

Table 1 Comparison of the types of support between the study groups

Type of support	Group		
	Tooth–implant (n=16)	Implant (n=19)	Tooth–tooth (n=28)
Point support	0	0	0
Linear support	0	0	14
Triangular support	0	1	9
Quadrangular support	5	14	4
Polygonal support	11	3	1

coping, the remaining silver layer on the internal surface was removed completely by 30% nitric acid. No retention force adjustment was required and, thus, the conditions for the retention force of all groups were the same. A cobalt–chrome–molybdenum metal framework enclosing the copings completely was produced. After inserting the primary crowns, the secondary crowns were luted intraorally in this metal framework by a composite cement (AGC® Cem, Wieland Dental, Pforzheim, Germany). The dentures were completed in acrylic, facings were added and the dentures were incorporated [16].

Patients were examined regularly. To collect updated clinical information, patients were recalled for a follow-up examination. For analysis in this study, data from an observation time of 24 months were used (Table 2).

Examination results were documented on standardized follow-up study sheets for implant-supported prostheses. For the abutment teeth, implants and restorations, the characteristics recorded were: probing pocket depth, tooth or implant mobility, presence of static and dynamic occlusal contacts and technical and biological complications and their treatment. In addition, patients' and dentists' satisfaction with the function and aesthetics of the dentures was recorded on a numerical rating scale (0–10).

Complications were divided into biological complications, for example, peri-implantitis, implant loss and tooth loss and technical failures, for example, loss of cementation, abutment screw loosening, loss of facing, fracture of resin denture teeth and fracture of framework or saddle.

Statistical analysis

Statistical analysis was performed using SPSS (version 16.0; Chicago, IL, USA). Descriptive data were expressed as means ±SD. The Kruskal–Wallis test was used to analyse possible differences between age and gender in the two study groups and in the control group. Kaplan–Meier survival curves were used to depict survival graphically [17, 18]. The probability of survival was calculated for biological (implant/abutment tooth loss, peri-implantitis) and technical complications. Statistical comparison of the survival curves from the three groups was performed with the logrank test [19]. Statistical significance was set at a p value of <0.05.

Table 2 Implant/abutment tooth-related and technical complications after 24 months

Type of complication	Group		
	Tooth–implant (n=16)	Implant (n=19)	Tooth–tooth (n=28)
Tooth loss	0	0	2
Endodontic treatment	0	0	1
Loss of cementation	0	1	0
Abutment screw loosening	1	2	0
Loss of facing	2	1	7
Fracture of resin denture teeth	0	0	0
Fracture of framework or saddle	0	0	0
Dropout	0	0	2

Results

Biological complications

In the ii group, two implants were lost after 1 and 9 months of use and two cases of peri-implantitis occurred after an observation time of 4 months. In the tt group, two teeth were lost after 21 and 23 months of use; one of these had root canal treatment. One abutment tooth of the tt group required endodontic treatment after 15 months of use. This group had two cases of dropout after 4 and 10 months. The Kaplan–Meier estimation in Fig. 1 shows the biological event rate for the two study groups.

Technical complications

Loss of facing was the most frequent technical complication: two occurred in tooth–implant-supported dentures (after 6 and 18 months), one in implant-supported dentures (after 6 months) and seven in tooth-supported dentures (after 22 to 24 months). Loss of cementation was reported for one double crown of the implant-supported dentures after 4 months. Screw loosening was documented once in

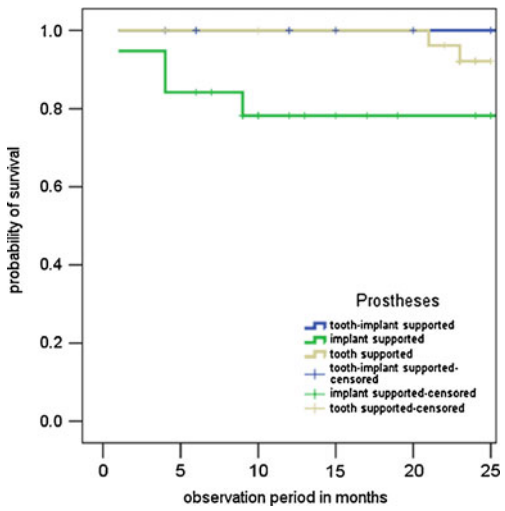

Fig. 1 Kaplan–Meier survival curves based on biological complications (implant/abutment tooth loss, peri-implantitis and root canal treatment)

the ti group (after 13 months) and twice in the ii group (after 17 and 24 months). Within 24 months, no fracture of resin denture teeth, framework or saddle, was observed in any group. Figure 2 shows the Kaplan–Meier estimation for technical complications. Using the Kruskal–Wallis test, no significant differences with regard to age or gender were found between the patients of the three groups.

The Kaplan–Meier survival curves revealed that the frequencies of the technical denture-related complications in the three groups were comparable. There was a tendency for implant and abutment tooth-related complications to be higher for exclusively implant-supported dentures. After 24 months, the differences between the three groups were not significant, however, and all DCRDs were still in use (Figs. 3, 4, 5, 6, 7 and 8).

The logrank test did not show significant differences between occurrence of technical complications in the ti group and the ii group (p=0.613), and comparison of these two study groups (ti and ii) with the tt group did not reveal significant differences with regard to technical failures (p= 0.709). When biological complications in the first two study groups were compared, the marginal p value of 0.058 was indicative of a tendency to higher biological complication rates for exclusively implant-supported DCRDs. When the ti group and the ii group were compared with the tt group, the p value was 0.100.

Discussion

In this retrospective study, treatment with DCRDs did not result in significant differences between the three groups investigated; there were few biological and technical failures during the observation time of 2 years.

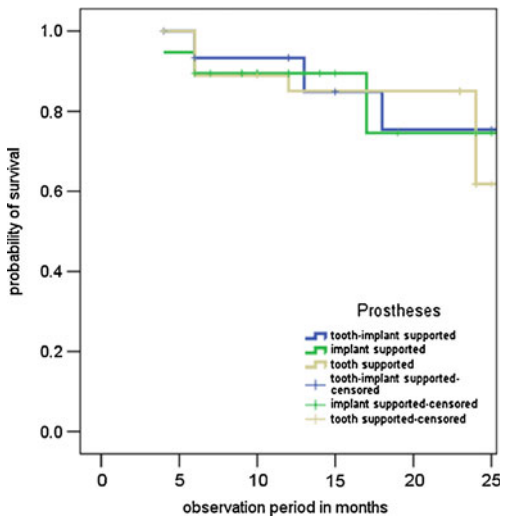

Fig. 2 Kaplan–Meier survival curves based on technical complications

Fig. 3 Prepared abutment teeth and two implants in strategic positions

Patients were selected with the objective of examining all patients with DCRDs supported exclusively on implants or on a combination of implants and natural teeth who were available for regular follow-up investigations. Most of our patients regard the clinic as their "general dentist" and did not attend for special treatment only. Consequently, few dropouts were expected.

Previous studies have described survival and prosthetic complications for implant-supported overdentures as mostly based on two or four interforaminal implants in the mandible. The most frequently used abutments were bars (round or milled), magnets and ball attachments [20]. Overdentures based on double crown attachments on implants have rarely been described [11–13].

The available literature gave no indication of significant differences between the survival of implant-supported overdentures with bar attachments or double crowns, although the DCRDs resulted in more favourable gingival conditions [11]. Because elderly patients, in particular, are fitted with this type of prosthesis, it should be borne in mind that double constructions seem to be easier to care for because they have no areas with difficult access for oral hygiene. The circular hygiene capability in the region of the implant can be compared with that of ball attachments. Wismeijer et al. [21] observed less bleeding for two implants with single spherical

Fig. 4 Basal view of DCRD supported by teeth and implants

Fig. 5 Occlusal view of DCRD supported by teeth and implants

attachments than for implants with bar constructions; this may result from accumulation of less plaque.

Another advantage of double crowns is the merits of flexible prosthetic treatment. After the loss of one abutment or with additional later implant insertion, the overdenture can be modified accordingly.

With regard to the comfort of chewing, overdentures retained on bars can drastically reduce the space available for tongue function. Relative to the construction of the metal framework, double crowns enable more delicate structuring of the overdenture [13].

Implant success and peri-implant conditions for prostheses with ball or double crown attachments did not differ in an investigation by Krennmair et al. [12], although the frequency of technical complications was significantly higher with ball attachments than with double crowns. In this study, technical complications with the abutment systems were loss of cementation and facings and screw loosening. All of these were easy to repair and did not reduce survival of the denture.

Follow-up studies on double crown-retained dentures supported exclusively on natural teeth report survival between 92% and 100% [22–25]. The number, position and distribution of the abutment teeth are factors that affect the survival of double crown-retained dentures [24]. An investigation that compared removable partial dentures retained on either conical crowns or parallel-sided crowns

Fig. 6 Four implants in strategic positions in the maxilla

Fig. 7 Basal view of DCRD supported by implants

found 15% with loosened cementation and no loss of facings for parallel-sided crowns during the first 2 years in use [26]. In this study, one case of loosened cementation occurred in the ii group. No loss of cementation was observed in the other examination groups during the observation time. Loss of facing occurred most often in the tt group (seven times), once in the ii group and twice in the ti group. Faults during the manufacturing process, or the fact that there was a relatively large range of abutment number, position, distribution, different kinds of support and the resulting different tension of the metal framework, may be an explanation of the different loss of cementation. Moreover, it has to be attended that the tt group had a higher number of cases than the other study groups.

Literature on tooth–implant-supported removable dentures retained on double crowns is rare. The small amount of literature describing combined tooth–implant-supported removable dentures on double crowns mostly combines double crowns with other kinds of attachment, for example root copings and ball attachments [6, 9]. Variation in denture design, anchorage system and residual dentition make comparisons difficult. Kaufmann et al. [9] analysed telescopic crowns and ball attachments as anchors for combined tooth–implant-supported removable partial dentures; survival of implants with telescopic crowns was 100% after 8 years

Fig. 8 Occlusal view of DCRD supported by implants

of observation. The technical complication rate was higher than in this investigation but it was not indicated whether they occurred on telescopic crowns or on ball anchors.

Only two studies were found that used exclusively double crowns as anchors for tooth–implant-supported removable partial dentures [7, 8]. Krennmair et al. [7] observed survival of 100% for teeth, implants and prostheses after a mean of 38 months. Nickenig et al. [8] investigated fixed and removable partial dentures supported by implants and teeth. After 10 years, fewer than 5% of implant abutments had biological or technical complications. The selection of remaining teeth and accurate planning of the strategic implants are very important to the success of this type of prosthetic solution, because there is a greater risk of biological complications for root canal-treated teeth or teeth with a reduced attachment level [8]. In this investigation, combination of implants and natural teeth using double crowns did not result in more biological and technical complications than for dentures retained exclusively on implants or natural teeth. Quite the contrary, there was a tendency to more biological complications in the ii group (p=0.058). There are various possible reasons for implant loss. For example, smoking or a maxillary sinus lift could be explanations in the present case. Altogether, in the ti group few prosthetic complications occurred and survival was 100%. This is comparable with results from other studies of removable dentures supported by teeth and implants in combination.

One limitation of the study design could be that several different dentists participated in the study and the dentures were fabricated in different dental laboratories. All the dentists were educated at this clinic and there was long and regular cooperation with the dental technicians. Although all the dentists and technicians participating in the study adhered to treatment guidelines for DCRDs supported by teeth and by implants, there could have been more or less experienced practitioners among them. Some technical complications, for example loss of cementation and loss of facing, could have resulted from this. This investigation is a case–control study, and the amount of scientific evidence is not high. The residual dentition of patients may, however, be highly different with regard to number and distribution over the arch, occlusal relation and periodontal status. Therefore, a well-designed randomized controlled trial could not be performed without severe restrictions on patient selection, which might not represent the complex clinical reality any more than it currently does.

Conclusions

This article reports 2-year results for a retrospective study indicating that double crowns can be recommended for implant and combined tooth–implant-retained dentures. It must, however, be kept in mind that, because of the number of uncontrolled confounders and the exploratory nature of the study, the results (e.g. p values) cannot be interpreted in a confirmatory sense but merely give an indication of which factors might cause complications. The results must, thus, be interpreted as a trend. To obtain significant results, long-term studies with larger sample sizes are required, because of the variety of biological and technical complications and the large number of risk factors for this type of denture.

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

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