Removable Dentures with Implant Support in Strategic Positions Followed for Up to 8 Years

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Purpose: The aim of this study was to analyze prosthetic maintenance in partially edentulous patients with removable prostheses supported by teeth and strategic implants. ***Materials and Methods:*** Sixty patients with removable partial prostheses and combined tooth-implant support were identified within the time period from 1998 to 2006. One group consisted of 42 patients (planned group) with a reduced residual dentition and in need of removable partial dentures (RPDs) or overdentures in the maxilla and/or mandible. They were admitted consecutively for treatment. Due to missing teeth in strategic important positions, one or two implants were placed to improve symmetrical denture support and retention. The majority of residual teeth exhibited an impaired structural integrity and therefore were provided with root copings for denture retention. A few vital teeth were used for telescopic crowns. The anchorage system for the strategic implants was selected accordingly. A second group of 18 patients (repair group) wearing RPDs with the loss of one abutment tooth due to biologic or mechanical failure was identified. These abutment teeth were replaced by 21 implants, and patients continued to wear their original prostheses. The observation time for planned and repair groups was 12 months to 8 years. All patients followed a regular maintenance schedule. Technical or biologic complications with supporting teeth or implants and prosthetic service were registered regularly. ***Results:*** Three maxillary implants were lost after loading and three roots with copings had to be removed. Biologic problems included caries and periodontal/peri-implant infection with a significantly higher incidence in the repair group ($P < .05$). Technical complications with the dentures were rather frequent in both groups, mostly related to the anchorage system (matrices) of root copings and implants. Maintenance and complications were observed more frequently in the first year after delivery of the denture than in the following 3 years ($P < .05$). No denture had to be remade. ***Conclusions:*** The placement of a few implants allows for maintaining a compromised residual dentition for support of RPDs. The combination of root and implant support facilitates treatment planning and enhances designing the removable denture. It also proves to be a practical rescue method. Technical problems with the anchorage system were frequent, particularly in the first year after delivery of the dentures. *Int J Prosthodont 2009;22:233–241.*

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Overdentures supported by tooth roots or implants are a frequent treatment modality. Implant-supported overdentures in the mandible are well-documented in clinical investigations and are suggested to be standard treatment.[1] In the past, before implants became a regular prosthetic therapy, remaining roots were maintained and used to prevent residual ridge resorption and discomfort with complete dentures.[2,3] A variety of root-supported overdentures

were described, including short copings with or without directly mounted precision attachments or individually fabricated cast gold copings.[4] In contrast to implant overdenture studies, those on root-supported overdentures are less frequent. They mostly focus on biologic treatment outcomes, such as caries and periodontal problems.[5–7] Simple root support appeared to be the treatment modality of choice if the structural integrity of residual teeth was highly compromised and investment in prosthetic rehabilitation of these teeth (ie, crowns, gold copings) became questionable. Fabrication of root copings with precision attachment for denture connection and retention was also reported by some authors.[3,4,8] In the 1980s, the so-called perio-overdenture was described in its most refined design.[8,9] This includes a symmetrical distribution of four or more tooth roots with gold copings and precision attachments, mostly located in the anterior jaw segment from left to right first premolars.

A highly reduced dentition does not allow for treatment with fixed prostheses unless an adequate number of implants can be placed, sufficient bone is available, and patients can afford the treatment. Therefore, removable dentures are still a frequent treatment modality.

A recent study with long-term results exhibited a high survival rate (80%) of root copings for overdenture support, with periodontitis, endodontic problems, caries, and root fractures being the reasons for failure.[10] A short literature review compared overdentures supported by natural roots or implants[11] and analyzed advantages and complications of both treatment modalities. Overdentures supported by roots appear to have a more limited prognosis than those supported by implants because of their greater susceptibility to caries and periodontal diseases.[6,7,12] Up to 35% of root copings exhibited caries, even in the presence of a high standard of oral hygiene. These roots were not covered by copings. Another study[13] found that caries was only a minor problem because small caries lesions could mostly be controlled using minor restorations and topical fluoride treatment. Some authors[6] found that caries development under overdentures could be inhibited completely through use of a daily application of chlorhexidine-fluoride gel. Other studies[11,14] indicated that periodontal complications are a major cause of abutment loss in overdenture wearers.

Some studies investigated passive and active tactile sensibility in overdenture wearers. By means of comparative measurements, they found that the threshold of minimal perceived direct pressure was significantly lower with overdentures supported by tooth roots than when supported by implants.[15,16] This is ascribed to the presence of receptors in the periodontal ligament. The perception capacity of interocclusal thickness, however, was not distinctly better with roots when compared to implants. The removable denture itself might cause this limitation in active tactile sensibility in spite of the presence of a periodontal ligament. It is assumed that oral function with implant overdentures is similar to root-supported overdentures even though the periodontal ligament is absent. Thus, the most important aspect in overdenture wearing appears to be improved stability of the prosthesis.

New information is available on double-crown retention (ie, telescopic tooth crowns, which appear to be used more often and better documented in clinical studies).[17] However, vital teeth with sufficient sound tooth structure for crown preparation are required. Unfavorable tooth axes cannot be corrected, overcontouring of teeth and dentures is a problem, and the technique is rather expensive. On the other hand, high denture stability was provided with telescopic crowns and posterior ridge resorption was less pronounced[18] when compared to dentures with clasp retention.

Regardless of whether gold copings with precision attachments or telescopic crowns are considered to be the treatment option, symmetrical support by the abutment teeth or roots is suggested. This is often not obtained with a minimal number of residual teeth, and additional support by placement of single implants in strategic positions to obtain improved overdenture stability is suggested.

The use of a fixed prosthesis with exclusive implant support in partially dentate patients has resulted in a positive long-term treatment outcome.[19] In fixed partial prosthodontics, the combination of tooth and implant support is also practiced, but it appears that more technical problems can be encountered.[20] In removable prosthodontics, a combined tooth/root and implant support system is described by only a few authors.[21,22] Objections to such a treatment modality are that implants are single standing, not rigidly splinted. A recent review summarized the literature available on this treatment modality.[23] This review mostly comprised single case reports on supporting implants for mandibular removable partial dentures (RPDs) with a unilateral or bilateral free-end situation.

The aim of the present study was to analyze survival and prosthetic treatment outcomes in partially edentulous patients with removable prostheses supported by tooth abutments and strategic implants.

Materials and Methods

Patients and Implants

This cohort study included 60 partially edentulous patients (33 men and 27 women, average age: 63 ± 7.9 years). Fifty-five patients had one removable denture

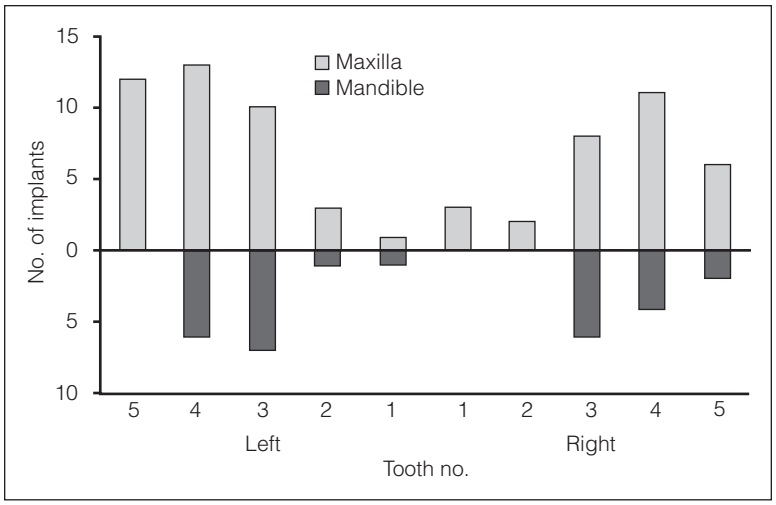

Fig 1 Distribution of all strategic implants in the maxilla and mandible.

in either the maxilla or mandible, while only five patients had a denture in both arches. The removable dentures were supported by both teeth and implants. Overall, 93 implants were placed in a standard surgical procedure with a delayed loading protocol (66 in the maxilla and 27 in the mandible). One or two implants were placed per denture with an average of 1.6 per patient. Three different implant systems were used: 68% were Strauman Dental Implant System (Straumann), 22% were Nobel Replace Tapered (Nobel Biocare), and 10% were Astra (Astra Zeneca). Figure 1 shows the distribution of all strategic implants in the maxilla and mandible. Implant length varied between 8 and 16 mm depending on the amount of bone available. Forty-six percent of implants had a length of 10 mm or less. In the maxilla, all implants were 8- to 10-mm long, while in the mandible, most implants were less than 10 mm in length. Implant diameter varied from 3.3 to 5.0 mm, with 35% of implants having narrow diameters (ie, a diameter of 3.3 or 3.5 mm). The length of these narrow-diameter implants was 10 mm or more.

When treatment started, the patients were in fair health conditions as follows: no diabetes dependent on insulin, bisphosphonates, irradiation or chemotherapy, congenital or acquired oral defects, Sjogren Syndrome, long-term intake of steroids, history of heart attack/chronic venous insufficiency during the last 12 months, or anticoagulation (thrombocyte aggregation inhibitors were accepted). Patients suffering from high blood pressure were not excluded if it was well-controlled by medications (Digoxin, B-blocker). A few patients had occasionally been prescribed antidepressive medications. Fifteen percent of patients claimed to be light smokers.

All patients gave their informed consent for the proposed treatment modality and covered the full cost of treatment themselves.

Prosthetic Treatment Concept

Among all 60 patients, 42 were identified who had strictly followed the original treatment plan (planned group). These patients presented with a highly compromised dentition with regard to the number of teeth, structural integrity, caries, and endodontic and periodontal problems. All Kennedy classes and subclasses of edentulism were present. The treatment plan consisted of placement of implants in strategic positions to improve retention and support of a removable denture. In the pretreatment phase, hopeless teeth were extracted, periodontal and endodontic treatment was performed, and new fillings were made. The number of remaining teeth that could be used for denture support varied from one to five per arch. The majority of teeth that could be maintained as denture abutments were broken, required endodontic treatment, or were already nonvital teeth. Therefore, these abutment teeth were prepared for cementation of root copings fabricated from gold alloy with posts and soldered ball anchors. A few vital teeth with sufficient structural integrity were prepared for telescopic crowns. Accordingly, the retention device for the implants was selected: either ball anchors were mounted or individual telescopes fabricated. A few molars were maintained and included in the denture framework by clasp retention. By means of one or two additional implants, a triangular or quadrangular support could be provided for the dentures. A further indication for a strategic implant was to replace one missing canine tooth in free-end situations. This resulted in a linear support system. The cast metal framework of the dentures was fabricated from a cobalt-chromium alloy. To obtain passive fit, the matrices of the ball anchors and secondary telescope crowns were mounted directly intraorally.

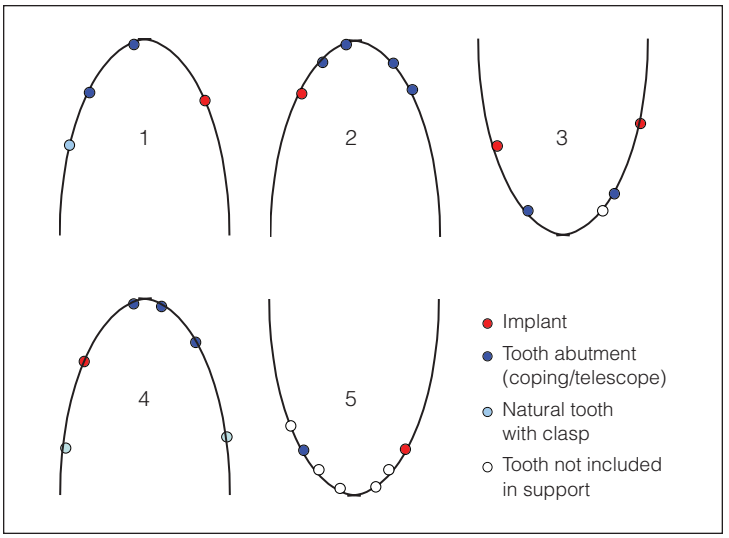

Fig 2 Examples of indications for strategic implants.

During the same time period, 18 patients received removable dentures and overdentures supported by tooth roots with cast gold copings. Each patient lost one strategic abutment, which was then replaced by a total of 21 implants (repair group). Patients continued to wear their original denture. They entered the present study at the time they received the rescue implant. Among all 60 patients, 15 were identified with bruxism habits in the pretreatment phase and were assigned to a splint therapy. At the end of therapy they received a night guard. Denture survival meant that the original denture had been in situ throughout the entire observation period and had not been remade. Minor adjustments and repairs were considered part of maintenance, but not as denture failure.

Indications for Strategic Implants

The indication for placement of a strategic implant can be summarized with regard to the distribution of the residual teeth as follows: *(1)* unilateral residual dentition, *(2)* exclusively anterior teeth and one or both canines missing, *(3)* unilateral or bilateral free-end situation with remaining canines, *(4)* only some anterior teeth and molars left in the maxilla, or *(5)* rescue implant for lost root coping in the repair group. Figure 2 shows a theoretical scheme of each indication. Due to the varying number of residual abutment roots, crowns, or teeth and different retention mechanisms, the dentures had different designs. They either resembled an RPD or an overdenture. If sufficient quadrangular support was provided, a horseshoe design was preferred for the maxillary denture. Otherwise, the denture was designed with a transpalatal major connector or a full palatal cover. The opposing arch exhibited a full natural dentition or fixed prosthesis supported by teeth and implants (27%) or an RPD/overdenture was present (65.5%). Only five complete dentures (8%) were found in the maxilla. Acrylic resin denture teeth were mounted to all prostheses. If a complete denture or overdenture was present in the opposing arch, a lingualized occlusal scheme was used.

Figures 3a to 3f show a clinical example of a patient with an RPD/overdenture and implant support in both arches.

Follow-up and Maintenance

All patients were included in a regular maintenance program with biannual recalls. These recall appointments included a checkup of oral hygiene, caries, and periodontal/peri-implant tissues. A dental hygienist performed any hygiene-related procedures, while a clinician was responsible for any prosthodontic service required. Crestal bone changes at mesial and distal implant sites were measured on single orthograd radiographs taken with film holders. The first radiograph, used as a baseline for the measurements, was taken when the denture was delivered; the second was taken after an observation period of 1 to 8 years.

All biologic and technical complications were recorded in the patients' charts throughout the entire observation time. Technical problems were classified into three categories, adapted from previous clinical studies.[21,24,25] These three categories are related to complications, failures, and repair of dentures:

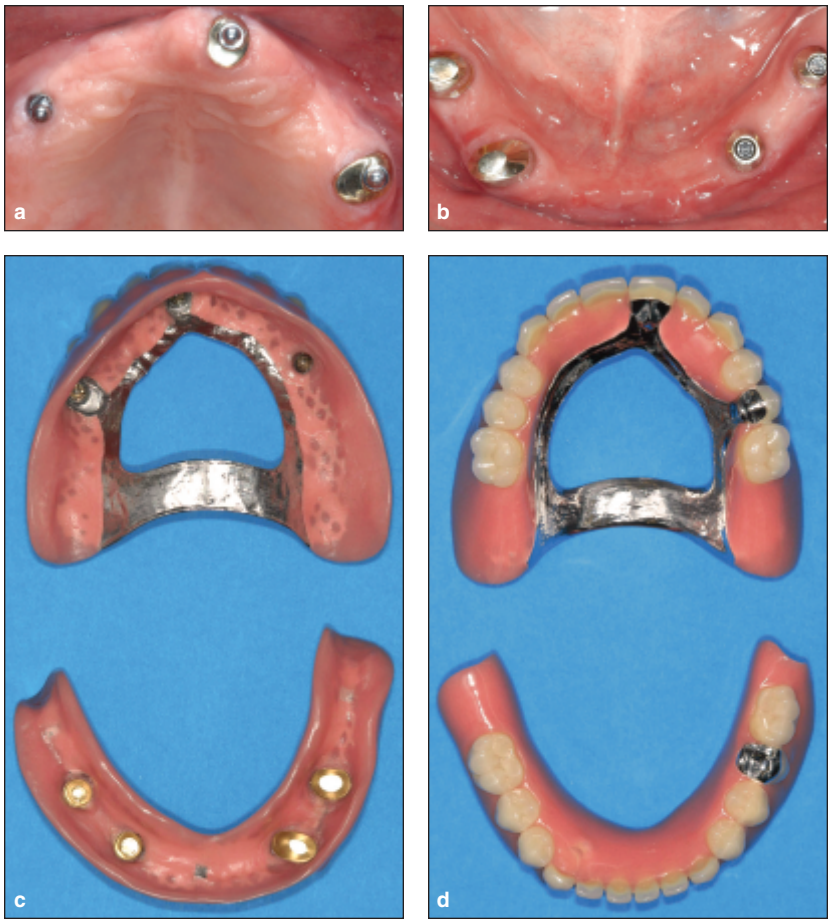

Fig 3 Patient case with dentures in both arches: **(a)** maxilla: two root copings and one implant with ball anchors; **(b)** mandible: two teeth and two implants with telescopic crowns; **(c and d)** inner and outer surfaces of dentures with metal framework, female retainers, overdenture design, and open palate in the maxilla.

1. Complications related to root copings, telescopic crowns, implant components, and anchorage devices:
   - Loose or lost cast gold coping/telescope with need of recementation
   - Loosening of implant abutment ball anchor or telescopes
   - Broken, loose, or lost female retainers followed by placement of new retainers
   - Tightening of female retainers

2. Mechanical and structural failures of the dentures:
   - Fracture of resin denture base
   - Fracture of teeth
   - Fracture of cast framework
   - Need for changes of prosthetic design followed by fabrication of new dentures

3. Prosthesis-related adjustments:
   - Sore spots
   - Relining of denture
   - Occlusal adjustments
   - Changes of tooth arrangement for esthetic reasons
   - Excessive wear of teeth

Statistical Analysis

Descriptive statistics were used for patients' demographics, distribution of roots, strategic implants, and the type of complications suffered. The chi-square test was applied for the comparison of crestal bone level changes and the incidence of prosthetic complications. All statistical analyses were done using SAS 8.2.

Results

During the observation period, three patients dropped out, one patient died (repair group), and two patients (planned group) were referred to a private clinician after 2 and 4 years, respectively, because they moved away. Their records were included in the results up to the time of their drop out. All other patients were available during the entire follow-up period. Forty-five dentures were placed in the maxilla and 20 in the mandible. A total of 101 root copings with precision attachments, seven telescopic crowns, 22 remaining molar teeth with clasps, and 93 implants supported the dentures. Eighty-six implants were provided with ball anchors

Table 1 Denture Design and Support

		Support			Design	
Group	No.	Quadrangular	Triangular	Linear	OD	RPD
Planned						
Maxilla	34	26	5	3	23	11
Mandible	9	3	3	3	1	8
Repair						
Maxilla	11	8	3	–	3	8
Mandible	11	–	2	9	1	10
Total	65	37	13	15	28	37

OD = overdenture; RPD = removable partial denture.

Table 2 Time of Service and Failures of Root Copings and Implants

Time	Dentures	Tooth abutments	Implants	Failures* root copings/implants
≤ 1 y	65	130	93	0/1
≤ 2 y	58	119	79	0/1
≤ 3 y	45	82	57	1/0
≥ 3 y	26	65	31	2/1

*Telescopic crowns did not fail.

Table 3 Biologic Complications Related to Time of Service in the Planned Group and Repair Group

	1 y	2 y	3 y	> 3 y	Total
Planned group					
Implants					
Perimucosal inflammation/ infection	4	1	0	0	5
Hyperplasia	0	0	1	0	1
Treatment with bone graft (BioOss)	0	0	0	1	1
Tooth roots					
Caries	1	1	0	0	2
Periodontitis	0	0	1	0	1
Hyperplasia	1	1	0	0	2
Total	6	3	2	1	12
Repair group					
Implants					
Perimucosal inflammation/ infection	0	0	0	3	3
Hyperplasia	0	0	0	0	0
Treatment with bone graft (BioOss)	0	0	0	0	0
Tooth roots					
Caries	0	3	2	1	6
Periodontitis	1	1	0	0	2
Hyperplasia	0	0	0	0	0
Total	1	4	2	4	11

and eight with telescopic crowns. The overall number of abutments and implants was 223, with an average of 3.35 per mandibular denture and 3.62 per maxillary denture. Table 1 summarizes the denture design (overdenture or RPD) for both groups and the type of support.

In the planned group, three maxillary implants (two Straumann, one Nobel Biocare) were lost during the observation period, one in the right maxillary canine after 2 months of loading and two in the right maxillary second premolar after 1.5 and 6 years in function, respectively. Two implants exhibited peri-implantitis; one was slightly mobile without signs of infection. These lost implants had lengths of 10 and 8 mm. One implant was replaced. Further, three gold copings were lost, one in the planned group after 2 years and two in the repair group after 4 or 5 years due to caries alone or with fracture of the root or post. Two root copings were replaced by rescue implants.

Denture survival was 100% in both the planned and repair groups. No new dentures were fabricated due to technical complications or abutment loss. The relative times of service and failures are shown in Table 2.

Table 3 shows a summary of biologic complications in the planned and repair groups. The ratio of biologic complications per denture in relation to the time of service was significantly different ($P = .045$) between the planned and repair groups, except during the first year. Caries incidence was particularly high in the repair group.

Table 4 Technical Complications Related to Time of Service

	1 y	2 y	3 y	> 3 y	Total
Implants					
No. of implants	93	79	57	31	
Patrix: loosening of ball anchor/telescope	5	0	0	7	12
Patrix: wear of ball anchor	1	2	0	1	4
Matrix: loosening of retainer	5	3	0	2	10
Matrix: tightening of retainer	16	11	2	9	38
Matrix: replacement or repair of retainer	5	5	2	10	22
Abutments					
No. of copings/telescopes	130	119	82	65	
Patrix: recementation of old coping	8	4	0	9	21
Patrix: wear of ball anchor	1	0	0	0	1
Matrix: loosening of retainer	0	1	0	3	4
Matrix: tightening of retainer	21	10	4	10	45
Matrix: replacement or repair of retainer	9	6	6	20	41
Repair of denture					
No. of dentures	65	58	45	26	
Fracture of resin denture base	1	0	1	1	3
Fracture of teeth	6	2	1	7	16
Redesign of existing denture	2	0	0	4	6
Adjustment of denture					
Sore spots	21	2	0	1	24
Relining of denture	5	4	1	5	15
Occlusal adjustment	19	6	1	2	28
Excessive wear of teeth	1	0	1	0	2
Total: all maintenance service	134	63	23	97	317

The mean value of change in crestal bone height at mesial and distal implant sites was –0.94 ± 1.3 mm in the maxilla, with 36% of implant sites exhibiting > 1 mm of loss, and –0.52 ± 0.9 mm in the mandible, with 22% of implant sites exhibiting < 1 mm of loss. The difference was statistically different. Altogether at 27 implant sites, no measurable changes were detected.

Table 4 gives an overview of all technical complications and services needed according to the three categories and related to the time of service. Findings of the planned and repair groups are collapsed into one table since the ratio of complications per denture in relation to the time of service was not significantly different. Also, a significant difference was not found between the maxilla and mandible. The incidence of maintenance and repair was high for the anchorage system. Complications for both root copings and implants were mostly related to tightening and replacement of the matrices.

Overall, the statistical analyses showed that a higher incidence of complications was noted in the first year after denture incorporation than in the following 2 years. The difference between the first year and the second and third years was statistically significant ($P = .037$ and $P = .03$, respectively). The variation in denture design, anchorage system, and residual dentition does not allow for further statistical comparison.

Discussion

Nowadays, clinicians face problems in deciding treatment for a highly reduced dentition. They are blamed for placing implants too quickly instead of maintaining teeth. While a recent study suggests that overdentures supported by roots may become obsolete and implants might be preferred,[26] another study showed that periodontally healthy teeth have a better survival rate than implants.[27] In fact, there is a dilemma with regard to maintaining a few residual teeth for placement of implants. From a biologic (periodontal) point of view, teeth or roots could often be maintained, but from a prosthodontic point of view, in many situations the dentition compromises the design and stability of removable dentures. A compromised design of RPDs may be one reason that RPDs are often not well accepted and worn by patients.[28] Thus, the present concept of using implants in strategic positions combines two intents: it contributes to the maintanance of residual teeth and enhances denture design with better denture retention and support. Costs are slightly increased by 7% to 10% with the placement of implants, but still, such removable dentures are considered to be a low cost therapy compared to fixed prostheses.

The present research is a case control study, and from a scientific point of view, the level of evidence is

not strong. However, the residual dentition of patients may be highly different with regard to the distribution over the arch, the interarch relation, structural integrity, and periodontal attachment loss. Therefore, a well-designed randomized controlled trial could not be done without strong restrictions in patient selection, which might not represent the complex clinical reality any more than it currently does.

In the present study, the incidence of biologic complications (caries, periodontal/peri-implant problems) is in accordance with results from studies previously mentioned.[6,7,12] In a more recent study with combined tooth-implant support and an exclusive double crown technique, more favorable biologic findings were reported for a group of 20 patients.[22] It cannot be concluded whether this difference can be ascribed to the type of retention mechanism or the selection of healthier abutment teeth with better-maintained structural integrity for telescopes. In the present study, the periodontal status of many teeth and roots were compromised with advanced attachment loss and a need for endodontic treatment. Therefore, they were selected to serve as root copings for overdenture support. It also has to be considered that 19 gold copings were lost in the repair group at various time periods (from 1 to 6 years in function) and as a consequence, strategic implants were placed. In spite of regular maintenance by these patients in the repair group, advanced periodontal disease (nine root copings) and caries (10 root copings) had caused 21 abutment failures, which were often combined with mechanical problems such as post and root fracture. One can speculate whether this repair group represents a particularly high-risk group for biologic failure and a more specific patient selection should be applied when root copings are planned.

A review paper suggests that bruxism might create an increased risk for implant failure, but there is some controversy regarding this concept.[29] The selection of short implants could be a major reason for implant loss, and using longer implants with a larger diameter could reduce the stress in the bone. Further, nightguards are recommended for bruxism patients. In the present study, one maxillary implant 10 mm in length was lost in a patient with bruxism habits.

Prosthetic results, as reported in the present study, were previously described for mandibular and maxillary implant overdentures using the same categories of complications,[16,18,19] while similar results on prosthetic complications of root copings are lacking. In fact, the incidence and type of complications were typical for removable dentures and in accordance with available observations that were mostly made with mandibular implant overdentures.[25,30,31] One study concluded that mandibular overdentures with Dalla Bona attachments were an accepted treatment option for edentulous patients, but maintenance and service were regularly required to ensure proper function.[32] In the present study, maintenance and complications were most often related to the anchorage systems, mostly to retightening of matrices, while service due to loosening of patrices was less frequent. Retightening of matrices may also reflect an increasing demand for strong retention, but is not necessarily an objective treatment need. The number of complications with patrices was lower and recementation was typical for root copings. Studies comparing round clip bars with ball anchors found more maintenance service with bar matrices (clip activation), while abutment screws of ball anchors had to be retightened.[33,34] In contrast, problems with clip bars and ball anchors (resilient retention) were more frequent compared to rigid (U-shaped) bars.[25] Similarly, rigid telescopic anchorage on teeth and implants appears to provide proper function with a lower incidence of maintenance.[22,35] Wear of ball anchors was observed five times in the present study. In the present study, patients with bruxism habits typically exhibited such complications, and four ball anchors on implants had to be replaced due to excessive wear. The reason for this finding was the fact that patients removed their dentures during the night and got in bruxing contact with the opposing dentition.

As reported in various clinical studies, it was observed that initially (ie, in the first two years) more prosthetic service had to be provided and the complication rate was significantly higher than in the following years.[24,25,30] A previous study compared three patient groups with different types of overdenture support.[21] Either they had only root copings or implants or a combination of the two. In the patients with only implants, less maintenance service was required. This group had a rigid bar connecting the implants, while single ball anchors were present in the other two groups. It was concluded that single abutments on teeth and implants do not provide as good of denture stability as a bar. In the present study, more technical problems were found with ball attachments if compared to the recent investigation with telescopic crowns on teeth and implants.[22] This could be ascribed to the high rigidity and stability provided by telescopic crowns, while ball anchors or clasps are rather semirigid in their function. The same authors reported[35] that more prosthetic service was needed for retentive attachments when compared to double crowns. Rigidity and stability of denture retention devices may reduce technical complications. Due to the unequal number of root copings, telescopic crowns, and clasps in the present study, a comparison between these anchorage systems was not reliable.

Conclusions

The placement of a few implants in combination with a compromised residual dentition facilitates the treatment planning of removable dentures and enables a better denture design. Triangular and quadrangular support can often be provided. It also proves to be a practical rescue method after loss of a strategic abutment tooth. Technical problems with the attachment system are frequent, particularly in the first year after delivery of the dentures, and maintenance service and aftercare are regularly required, even in the well-planned treatment group.

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