Survival of Double-Crown-Retained Dentures Either Tooth-Implant or Solely Implant-Supported: An 8-Year Retrospective Study

Stefanie Schwarz, Dr. med. dent.;* Gunda Bernhart, Dr. med. dent.;†
Alexander Jochen Hassel, Prof. Dr. med. dent.;‡ Peter Rammelsberg, Prof. Dr. med. dent.§

ABSTRACT

Purpose: To compare survival and incidence of complications for solely implant-supported double-crown-retained dentures (DCRDs) and combined tooth-implant-supported DCRDs for restoration of a complete jaw.

Materials and Methods: Patients were consecutively admitted to treatment at the Department of Prosthodontics, University of Heidelberg, during a time period from 2003 to 2011. Schedule and unscheduled visits were recorded on standardized documentation forms. Age, gender, location of implants, number of abutment teeth, jaw, and antagonist were assessed as possible factors affecting the number of complications per patient.

Results: Fifty-five patients with 66 DCRDs on 209 implants and 102 teeth were included. Of these, 30 dentures on 129 implants were solely implant-supported whereas the other 36 were combined tooth–implant-supported. During an observation period of up to 8.3 years (mean 3.4 years; SD 1.9) superstructure survival was 93.3% for the solely implant-supported DCRDs and 100% for the combined tooth–implant-supported DCRDs. Survival without major complications was 86.7% and 83.3%, respectively. Gender and location of both superstructure and implants were statistically associated with a greater number of complications.

Conclusion: Within the limitations of this exploratory retrospective study, not only solely implant-supported DCRDs but also superstructures combining remaining teeth and implants within DCRDs might be a reliable treatment option for elderly patients. Prospective randomized clinical trials are needed to confirm this, however.

KEY WORDS: DCRD, dental implants, double crowns, removable prostheses, survival

INTRODUCTION

Edentulism and severely reduced dentition are still major concerns for elderly patients, because functional and esthetic deficits of the orofacial system result in reduced chewing ability and reduced quality of life.[1,2] Oral rehabilitation by insertion of dental implants may help to improve this situation.[3–6]

The wide range of treatment options for edentulous jaws includes minimum intervention, for example, only one to three implants in the mandible supporting dentures with magnets, ball attachments, milled or shaped bars, or locator attachments,[7–13] or double-crown, bar-retained, or fixed dentures supported by 4–8 implants,[14–18] up to maximum intervention, for example, replacing each missing tooth with an implant.

In the past, in cases of reduced dentition remaining roots were maintained and treated with root copings, clasp prostheses, or double crowns.[19–21] A study of 16 male patients showed, as early as 1978, that natural teeth remaining in the mandible may prevent alveolar bone loss and that oral tactile sensitivity is enhanced.[22]

*Dentist, assistant professor, Department of Prosthodontics, University of Heidelberg, Heidelberg, Germany; †dentist, assistant professor, Department of Prosthodontics, University of Heidelberg, Heidelberg, Germany; ‡dentist, associate professor, Department of Prosthodontics, University of Heidelberg, Heidelberg, Germany; §dentist, director, Department of Prosthodontics, University of Heidelberg, Heidelberg, Germany

Reprint requests: Dr. Stefanie Schwarz, Department of Prosthodontics, University of Heidelberg, Im Neuenheimer Feld 400, 69120 Heidelberg, Germany; e-mail: stefanie.schwarz@med.uni-heidelberg.de

Conflict of interest and source of funding statement: The authors declare they have no conflict of interests. This study was funded by the authors and their institution.

DOI 10.1111/cid.12023

Depending on the number and position of the remaining teeth, however, the stability and retention of single root-supported dentures may be poor.[23]

Combining teeth with a limited number of implants in strategic positions for removable dentures might result in similar problems.[24] A few studies with root copings, ball attachments, and double crowns as connecting elements have been reported in the literature. Kaufmann and colleagues, in a cohort study on 60 partially edentulous patients, treated the remaining teeth with root copings or telescopic crowns and showed that insertion of one or two implants may improve symmetrical denture support.[25] Although the number of prosthetic complications in this study was high, in 2005 Mijiritsky and colleagues reported 100% implant survival and minor prosthetic complications after treating 15 patients with combined tooth–implant-supported dentures.[26]

Combining remaining teeth with implants inserted in strategic positions, by fabrication of double-crown-retained dentures (DCRDs), could enable polygonal abutment arrangements[27] and, therefore, stabilize the superstructure.[28]

DCRDs supported solely on teeth are known to be a successful treatment option, even over long periods of observation.[29–31] Advantages are ease of accessibility for dental hygiene, the possibility of extraoral repair, and extensibility in cases of tooth loss. Solely implant-supported DCRDs, however, are less often described in the literature[32] and, unfortunately, only a few case reports and clinical studies are available on the survival of, and incidence of complications for, combined tooth and implant-supported DCRDs.[33–35] Mijiritsky's review on implants in conjunction with removable partial dentures in 2007 therefore mostly comprised single case reports on implant-supported removable partial dentures in the mandible.[24]

The objective of this exploratory retrospective study was, therefore, to assess the incidence of superstructure complications for solely implant-supported and for combined tooth–implant-supported DCRDs fabricated, for restoration of a complete jaw, at the Department of Prosthodontics in the years 2003 to 2011, with special focus on comparison of the incidence of complications for solely implant-supported and combined tooth–implant-supported DCRDs. Furthermore, analysis of the collected data was performed to identify factors affecting the number of complications per patient.

MATERIALS AND METHODS

Patient Population and Data Collection

Patients of both sexes seeking treatment at the Department of Prosthodontics, University of Heidelberg, between 2003 and 2011, and who fulfilled the inclusion criteria, participated in this study. The study was a retrospective analysis of ongoing documented material. Data were extracted with the aid of a data-extraction sheet. The ongoing observation study, which was approved by the regional ethics committee (27/2005), documents all implants and suprastructures inserted and fabricated at the Department of Prosthodontics, Heidelberg.

The inclusion criteria for this analysis were being edentulous or having reduced dentition in the mandible or maxilla and wishing prosthetic treatment, including the insertion of dental implants to increase the number of abutments in strategic positions. Furthermore, both implants and denture had to be placed at the Department of Prosthodontics, and the observation period had to be a minimum of 6 months after prosthetic restoration. Only DCRDs with secondary crowns fabricated by the galvanoforming technique on implants of one manufacturer (Straumann GmbH, Basel, Switzerland) were included. Immediate or early loading of the implants was excluded from the study; only conventional loading was allowed. All patients were informed in detail about the study procedure and signed an informed consent form. Furthermore, all patients were treated in accordance with conventional clinical procedures, and the course of treatment and follow-up examinations was documented by use of standardized documentation forms.

Technical Procedure

All teeth underwent clinical and radiographic examination before planning number and position of the abutments supporting the DCRD. Only teeth that fulfilled the criteria according to the recommendation of the decision-making chart of Avila and colleagues[36] were included in the study. Following these guidelines it could also be realized, that implants were only inserted in periodontal healthy sites. The implants were placed in accordance with the standard procedures recommended by the manufacturer; a surgical splint was used to ensure the strategic planned positions. The healing period was 3 months for all implants in the mandible and 6 to 9 months for maxilla implants. All patients were treated

in accordance with the guidelines of the department. The taper of the prepared teeth was approximately 6° and primary crowns were cast with precious alloys and milled with a taper of approximately 2°. For all impressions polyether material was used. Secondary crowns were fabricated by the galvanoforming technique and cobalt–chrome–molybdenum metal frameworks completely enclosing these copings were produced. After permanent fixing of the primary crowns to secure passive fit of the suprastructure, the secondary crowns were luted intraorally to the cobalt–chrome–molybdenum metal frameworks. The facings of the dentures were all made of acrylic (Figure 1).

Each dentist maintained baseline documentation and documentation for subsequent recalls after 6 months, 12 months, and then at 1-year intervals, on standardized documentation forms. Patients were requested to consult the clinic immediately on recognition of any complication; both scheduled and unscheduled visits were recorded.

Follow-up included clinical examination and recording of both technical or biological complications and their treatment. In this clinical trial any intervention for DCRDs was counted as a complication. Occurrence of complications and the measures implemented were documented separately on standardized complication forms. Depending on the extent of the complication the DCRDs were repaired chairside or at the dental laboratory. If repair was not possible the DCRD was remade.

Figure 1 *A*, Preparation of remaining teeth. *B*, Try-in of the primary crowns on the teeth before pick-up impression. *C*, Screwing-in of the abutments and cementation of the primary crowns on teeth. *D*, Try-in of the secondary crowns (fabricated by the galvanoforming technique). *E*, Try-in of the luted framework, control of passive fit. *F*, Pick-up impression on secondary crowns and luted framework. *G*, Interior view of combined tooth–implant-supported double-crown-retained dentures. *H*, Close-up of patient smile.

Data Management and Statistical Analysis

All data were analyzed by the use of SPSS 19.0 (SPSS Inc., Chicago, IL, USA). Kaplan–Meier curves were plotted to depict survival without major complications for the solely implant-supported DCRDs and the combined tooth–implant-supported dentures, and implant survival for both groups. For statistical comparison of the survival curves the log rank test was used. Statistical significance was set at a p value of <0.05.

A linear general estimation equation (GEE) model with dependent variable "number of complications per patient" was calculated. As independent variables "age" (in years), "gender" (male/female), "location of implants" (unilateral/bilateral), "number of abutment teeth" (number), "jaw" (maxilla/mandible), and "antagonist" (fixed/removable/complete denture) were all entered in the model. In a backward elimination process variables with a p value exceeding $p = .15$ were eliminated stepwise from the model until all remaining variables had a p value of 0.15 or smaller. The hypothesis of this analysis was that there is no difference between the complication rates of solely implant-supported and combined tooth–implant-supported DCRDs.

RESULTS

A total of 55 patients with 66 dentures on 209 implants and 102 teeth fulfilled the inclusion criteria and were included in the statistical analysis. Twenty-one patients were edentulous and 34 had remaining teeth in one or both jaws. The proportion of males was slightly higher (65.2%) and patients were slightly older (mean age 65.2 years, standard deviation [SD] 8.9) than the average for patients at the Department of Prosthodontics. Of all, one patient was lost to follow-up in 2007, two patients in 2008, and further nine patients had the last recall in 2010. The other 43 patients attended the last follow-up examination between June 2011 and May 2012.

Patients were retrospectively classified into two groups. Group 1 (solely implant-supported) included 30 dentures on 129 implants. The overall number of abutments was 4.2 ± 0.6 (range 3–6). Group 2 (combined tooth–implant-supported) included 36 dentures on 80 implants and 102 teeth. The overall number of abutments was 5.2 ± 1.4 (range 2–9). A total of 42 dentures were placed in the maxilla; of these, 18 were solely implant-supported. Twenty-four superstructures were inserted in the mandible, 12 in each group.

During a suprastructure observation period of up to 8.3 years (mean 3.4 years; SD 1.9), two superstructures were lost in group 1 because for one patient all the implants had failed and for the other patient irrepairable loss of retention of the superstructure occurred; superstructure survival was, therefore, 93.3% for solely implant-supported DCRDs and 100% for combined tooth–implant-supported DCRDs. Survival without major complications was 86.7% in group 1 and 83.3% in group 2. Estimated cumulative survival in group 1 was 92.3% after 2 years and 78.5% after 5 years and in group 2 was 93.3% after 2 years and 82.9% after 5 years (Figure 2). During the observation period no complications occurred for 16 DCRDs in group 1 (53.3%) and 14 DCRDs in group 2 (38.9%). The number and kind of major and minor complications per patient are listed in Tables 1 and 2. For a total of 21 patients the first complication occurred within the first 2 years of observation (9 in the first year, 12 in the second). In the following years the incidence of first complications decreased to four per year after 3 and 4 years, to six after 5 years and to one after 6 years.

The GEE showed that locations of implants and superstructure and patient gender were statistically significantly associated with the number of complications;

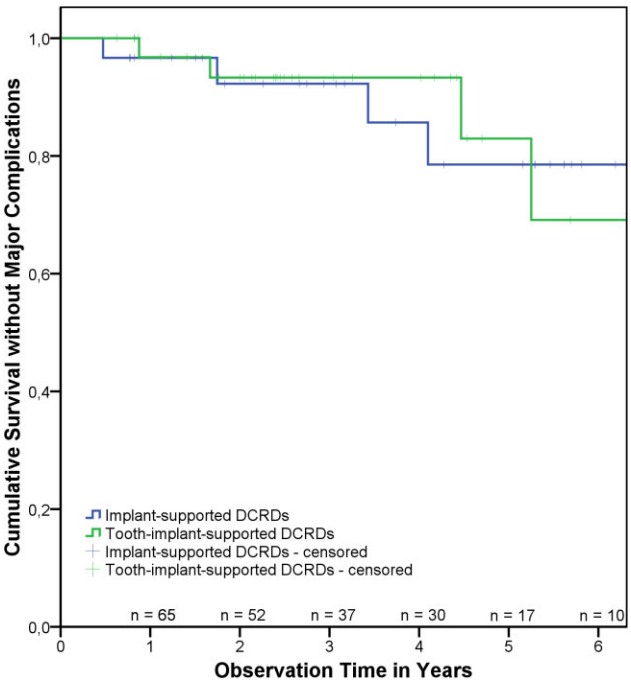

Figure 2 Six-year-Kaplan–Meier superstructure survival curves without major complications for the groups "implant-supported double-crown-retained dentures (DRCDs)" and "tooth-implant-supported DCRDs"; ("*n*" = number of patients attending the recall).

TABLE 1 Description of Major and Minor Complications of the Groups "Solely Implant-Supported DCRDs," "Combined Tooth-Implant-Supported DCRDs," and "All DCRDs"

Kind of Complication	Group 1	Group 2	Total
Major complication			
Loss of superstructure after implant failure	1	0	1
Loss of retention of the superstructure	1	2	3
Fracture of the superstructure framework or base	1	1	2
Major rework of the framework after reimplantation	1	1	2
Change of all acrylic teeth and facings	0	2	2
Minor complication			
Chipping or fracture of acrylic	5	11	16
Repair of facings	7	20	27
Relining of the superstructure	0	3	3
Refixing of the abutment	3	0	3

TABLE 2 Description of the Number of Complications per Patient of the Groups "Solely Implant-Supported DCRDs," "Combined Tooth-Implant-Supported DCRDs," and "All DCRDs"

Number of Complications per Patient	Group 1	Group 2	Total
0	16	14	30
1	10	12	22
2	3	2	5
3	1	8	9

more complications were associated with situations in which the implants were placed unilaterally, with superstructures placed in the maxilla and with male gender (Table 3). The independent variables antagonist ($p = .595$) and age ($p = .170$) were removed from the model in the backward elimination process.

DISCUSSION

The hypothesis of this retrospective analysis could be confirmed. The incidence of complications for solely implant-supported and combined tooth–implant-

TABLE 3 General Estimation Equation Model for the Dependent Variable "Number of Complications per Patient"

			95% Wald Confidence Interval	
Factor	Exp (B)	Significance	Minimum	Maximum
Gender				
Men	0.811	0.000	0.367	1.256
Women	1	—	—	—
Location				
Maxilla	0.447	0.020	0.071	0.824
Mandible	1	—	—	—
Implant location				
Unilateral	0.879	0.001	0.372	1.387
Bilateral	1	—	—	—
Number of abutments	0.110	0.125	–0.031	0.251
(Scale)	0.755	—	—	—

supported DCRDs did not differ significantly in this exploratory study. Furthermore, analysis of the collected data showed that the factors gender and location of both dentures and implants affected the number of complications per patient.

Several studies on solely implant-supported superstructures have been reported in the literature. Bars and ball attachments are the most common treatment options, and the amount of literature on DCRDs is only small. There are, unfortunately, even fewer reports on combined tooth–implant-supported DCRDs. In a retrospective study of survival and incidence of complications for combined tooth–implant-supported fixed ($n = 178$) and removable partial dentures ($n = 51$) on 459 implants and 449 teeth, Nickenig and colleagues,[28] in 2008, concluded there was no difference between the DCRDs and the fixed dentures. Krennmair and colleagues,[34] in a retrospective study of 22 patients with DCRDs on 48 teeth and 60 implants, after a mean observation period of 3.2 years, reported 100% survival of the superstructures. The same group, in a prospective randomized trial with 51 patients, compared survival and success for solely implant-supported overdentures on milled bars or telescopic crowns on four implants in the edentulous mandible.[37] A total of 25 patients had received telescopic crowns whereas the other 26 patients had received milled bars. After observation for 3 years the mean annual number of interventions/year/patient was 0.45 for the telescopic anchoring system compared with 0.41 for the milled bar group. A total of 58 complications occurred, with no significant difference between the two groups. The most common complications in the telescopic group were matrix deactivation, fracture/renewal of acrylic teeth, denture margin adaptation, and rebasing of denture or opposite denture. The results of Krennmair and colleagues are comparable with those in this study – total renewal of facings 40.9% and total fracture of acrylic teeth 24.2% were the most common complications in both groups.

In clinical studies of solely tooth-supported DCRDs the factors number, distribution, and position of the abutment teeth affected survival of DCRDs.[38] Although comparable to a limited extend only, the results of this retrospective study are similar – the location of the implants had a significant effect on the number of complications per patient. Placing the implants unilaterally resulted in a greater amount of aftercare. A possible reason might be the different resilience of natural teeth and implants and the resulting stress or tension within the superstructure. As a consequence, it might be useful to place strategic implants on both sides of one jaw to secure the stability of the superstructure.

DCRDs placed in the maxilla in this study resulted in a greater number of complications. According to the literature, the number of failures seems, in general, to be higher for implant-retained overdentures in the maxilla. Hutton and colleagues,[39] in a 3-year follow-up study in 1995, reported overdenture failures of 3.3% in the mandible and 27.6% in the maxilla. However, because of different treatment procedures, patient populations, and evaluation criteria the results are comparable to a limited extent only.

Furthermore, in this trial male patients had more complications than females. A reason might be the higher bite forces of men.[40,41] Another reason might be more careful behavior of women regarding the superstructure.

This study had some limitations. It is a retrospective analysis based on patient charts and documentation forms. Dentists with different clinical experience, and different dental technicians, participated in the study. This could have resulted in some of the technical complications. However, all clinicians adhered to the treatment guidelines for DCRDs of the Department of Prosthodontics.

Combining remaining teeth and implants has several advantages; high functionality with the possibility of extension after abutment loss, compensation of nonparallel tooth axes, preferred polygonal abutment arrangement and ease of cleaning seem to be the most important objective advantages. However, keeping one or a few remaining teeth, and including them in the new superstructures might be an important psychological advantage for many elderly patients who might not wish to be "toothless." Furthermore, the presence of at least one or two remaining teeth secures tactility and might be a helpful sensor enabling avoidance of functional overload that could occur with solely implant-supported superstructures.

CONCLUSION

The results of this retrospective study suggest that both solely implant-supported and combined tooth–implant-supported DCRDs result in high survival and success. Complications depended on patients' gender and location of both implants and superstructures. Keeping in mind the reduced physical, psychological, and financial

stress on elderly patients when remaining teeth may be included in new implant-supported superstructures, not only implant-supported DCRDs, but also combined tooth–implant-supported might be a suitable treatment option. Prospective randomized clinical trials are needed to confirm this, however.

ACKNOWLEDGMENTS

We thank Ian Davies, copy editor, for language revision.

REFERENCES

1. van Waas MA. The influence of psychologic factors on patient satisfaction with complete dentures. J Prosthet Dent 1990; 63:545–548.
2. Meijer HJ, Raghoebar GM, Van't Hof MA, Geertman ME, Van Oort RP. Implant-retained mandibular overdentures compared with complete dentures; a 5-years' follow-up study of clinical aspects and patient satisfaction. Clin Oral Implants Res 1999; 10:238–244.
3. Awad MA, Feine JS. Measuring patient satisfaction with mandibular prostheses. Community Dent Oral Epidemiol 1998; 26:400–405.
4. Bakke M, Holm B, Gotfredsen K. Masticatory function and patient satisfaction with implant-supported mandibular overdentures: a prospective 5-year study. Int J Prosthodont 2002; 15:575–581.
5. Meijer HJ, Raghoebar GM, Van't Hof MA. Comparison of implant-retained mandibular overdentures and conventional complete dentures: a 10-year prospective study of clinical aspects and patient satisfaction. Int J Oral Maxillofac Implants 2003; 18:879–885.
6. Thomason JM, Lund JP, Chehade A, Feine JS. Patient satisfaction with mandibular implant overdentures and conventional dentures 6 months after delivery. Int J Prosthodont 2003; 16:467–473.
7. Thomason JM, Feine J, Exley C, et al. Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients – the York Consensus Statement. Br Dent J 2009; 207:185–186.
8. Cordioli G, Majzoub Z, Castagna S. Mandibular overdentures anchored to single implants: a five-year prospective study. J Prosthet Dent 1997; 78:159–165.
9. Walton JN, Glick N, Macentee MI. A randomized clinical trial comparing patient satisfaction and prosthetic outcomes with mandibular overdentures retained by one or two implants. Int J Prosthodont 2009; 22:331–339.
10. Harder S, Wolfart S, Egert C, Kern M. Three-year clinical outcome of single implant-retained mandibular overdentures – results of preliminary prospective study. J Dent 2011; 39:656–661.
11. Vercruyssen M, Marcelis K, Coucke W, Naert I, Quirynen M. Long-term, retrospective evaluation (implant and patient-centred outcome) of the two-implants-supported overdenture in the mandible. Part 1: survival rate. Clin Oral Implants Res 2010; 21:357–365.
12. Rentsch-Kollar A, Huber S, Mericske-Stern R. Mandibular implant overdentures followed for over 10 years: patient compliance and prosthetic maintenance. Int J Prosthodont 2010; 23:91–98.
13. Ueda T, Kremer U, Katsoulis J, Mericske-Stern R. Long-term results of mandibular implants supporting an overdenture: implant survival, failures, and crestal bone level changes. Int J Oral Maxillofac Implants 2011; 26:365–372.
14. Mertens C, Steveling HG. Implant-supported fixed prostheses in the edentulous maxilla: 8-year prospective results. Clin Oral Implants Res 2011; 22:464–472.
15. Chiapasco M, Gatti C. Implant-retained mandibular overdentures with immediate loading: a 3- to 8-year prospective study on 328 implants. Clin Implant Dent Relat Res 2003; 5:29–38.
16. Eliasson A, Blomqvist F, Wennerberg A, Johansson A. A retrospective analysis of early and delayed loading of full-arch mandibular prostheses using three different implant systems: clinical results with up to 5 years of loading. Clin Implant Dent Relat Res 2009; 11:134–148.
17. Ortorp A, Jemt T. Early laser-welded titanium frameworks supported by implants in the edentulous mandible: a 15-year comparative follow-up study. Clin Implant Dent Relat Res 2009; 11:311–322.
18. Eitner S, Schlegel A, Emeka N, Holst S, Will J, Hamel J. Comparing bar and double-crown attachments in implant-retained prosthetic reconstruction: a follow-up investigation. Clin Oral Implants Res 2008; 19:530–537.
19. Behr M, Zeman F, Passauer T, et al. Clinical performance of cast clasp-retained removable partial dentures: a retrospective study. Int J Prosthodont 2012; 25:138–144.
20. Stober T, Bermejo JL, Beck-Mussoter J, et al. Clinical performance of conical and electroplated telescopic double crown-retained partial dentures: a randomized clinical study. Int J Prosthodont 2012; 25:209–216.
21. Monfrin SB, Previgliano V, Ceruti P, Preti G. A new coping for overdentures. Part 2: preliminary results of a clinical study. Int J Prosthodont 2007; 20:179–180.
22. Crum RJ, Rooney GE Jr. Alveolar bone loss in overdentures: a 5-year study. J Prosthet Dent 1978; 40:610–613.
23. Mericske-Stern R. Oral tactile sensibility recorded in overdenture wearers with implants or natural roots: a comparative study. Part 2. Int J Oral Maxillofac Implants 1994; 9:63–70.
24. Mijiritsky E. Implants in conjunction with removable partial dentures: a literature review. Implant Dent 2007; 16:146–154.
25. Kaufmann R, Friedli M, Hug S, Mericske-Stern R. Removable dentures with implant support in strategic positions followed for up to 8 years. Int J Prosthodont 2009; 22: 233–241.

26. Mijiritsky E, Ormianer Z, Klinger A, Mardinger O. Use of dental implants to improve unfavorable removable partial denture design. Compend Contin Educ Dent 2005; 26: 744–746.
27. Mitrani R, Brudvik JS, Phillips KM. Posterior implants for distal extension removable prostheses: a retrospective study. Int J Periodontics Restorative Dent 2003; 23:353–359.
28. Nickenig HJ, Spiekermann H, Wichmann M, Andreas SK, Eitner S. Survival and complication rates of combined tooth–implant-supported fixed and removable partial dentures. Int J Prosthodont 2008; 21:131–137.
29. Wenz HJ, Hertrampf K, Lehmann KM. Clinical longevity of removable partial dentures retained by telescopic crowns: outcome of the double crown with clearance fit. Int J Prosthodont 2001; 14:207–213.
30. Grossmann AC, Hassel AJ, Schilling O, Lehmann F, Koob A, Rammelsberg P. Treatment with double crown-retained removable partial dentures and oral health-related quality of life in middle- and high-aged patients. Int J Prosthodont 2007; 20:576–578.
31. Wöstmann B, Balkenhol M, Weber A, Ferger P, Rehmann P. Long-term analysis of telescopic crown retained removable partial dentures: survival and need for maintenance. J Dent 2007; 35:939–945.
32. Bernhart G, Koob A, Schmitter M, Gabbert O, Stober T, Rammelsberg P. Clinical success of implant-supported and tooth–implant-supported double crown-retained dentures. Clin Oral Investig 2012; 16:1031–1037.
33. Hug S, Mantokoudis D, Mericske-Stern R. Clinical evaluation of 3 overdenture concepts with tooth roots and implants: 2-year results. Int J Prosthodont 2006; 19:236–243.
34. Krennmair G, Krainhöfner M, Waldenberger O, Piehslinger E. Dental implants as strategic supplementary abutments for implant-tooth-supported telescopic crown-retained maxillary dentures: a retrospective follow-up study for up to 9 years. Int J Prosthodont 2007; 20:617–622.
35. Koller B, Att W, Strub JR. Survival rates of teeth, implants, and double crown-retained removable dental prostheses: a systematic literature review. Int J Prosthodont 2011; 24: 109–117.
36. Avila G, Galindo-Moreno P, Soehren S, Misch CE, Morelli T, Wang HL. A novel decision-making process for tooth retention or extraction. J Periodontol 2009; 80:476–491.
37. Krennmair G, Sütö D, Seemann R, Piehslinger E. Removable four implant-supported mandibular overdentures rigidly retained with telescopic crowns or milled bars: a 3-year prospective study. Clin Oral Implants Res 2012; 23: 481–488.
38. Eisenburger M, Gray G, Tschernitschek H. Long-term results of telescopic crown retained dentures – a retrospective study. Eur J Prosthodont Restor Dent 2000; 8:87–91.
39. Hutton JE, Heath MR, Chai JY, et al. Factors related to success and failure rates at 3-year follow-up in a multicenter study of overdentures supported by Brånemark implants. Int J Oral Maxillofac Implants 1995; 10:33–42.
40. Palinkas M, Nassar MS, Cecílio FA, et al. Age and gender influence on maximal bite force and masticatory muscles thickness. Arch Oral Biol 2010; 55:797–802.
41. Koç D, Doğan A, Bek B. Effect of gender, facial dimensions, body mass index and type of functional occlusion on bite force. J Appl Oral Sci 2011; 19:274–279.