Implant-assisted removable partial dentures as an alternative treatment for partial edentulism: a review of the literature

Konstantinos Chatzivasileiou, DDS, MSc ▪ Eleni Kotsiomiti, DDS, Dr. Dent ▪ Ioannis Emmanouil, DDS, Dr. Dent

This study reviewed the current literature concerning implant-assisted removable partial dentures (RPDs) in order to present the existing knowledge about performance issues. An electronic search was conducted on the PubMed database for published English-language articles that contained information about implant-assisted RPDs. A review of these articles indicated that the combination of dental implants with RPDs constitutes a cost-efficient prosthetic protocol that can offer solutions to problematic aspects of treatment with removable partial dentures. Well-designed studies are still needed to provide robust evidence on critical issues, such as design guidelines, long-term survival of implants associated with RPDs, and their effect on patients' quality of life.

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Epidemiological data indicate that in industrialized countries the percentage of complete edentulism in the general population is gradually decreasing in all age groups.[1-3] This finding indicates that more individuals will retain a number of teeth even in advanced age; therefore, the need for treatment of partially edentulous patients is expected to increase.

There are many ways to treat partially edentulous patients. If tooth-supported fixed partial dentures cannot be constructed due to an unfavorable number and/or distribution of teeth, removable partial dentures (RPDs) are typically prescribed. In the last few decades, dental implants have become a valuable option for prosthodontic rehabilitation. Longitudinal studies have demonstrated that implant prostheses represent a predictable and successful restorative solution for these cases.[4-6] However, these prosthodontic modalities cannot always be realized due to several factors, such as a patient's compromised general health, anatomical makeup, financial limitations, and/or personal preferences. The use of RPDs has been associated with poor patient acceptance due to lack of stability in part due to the rotation of the prosthesis seated on top of soft tissue, compromised function caused by discomfort upon loading, and poor esthetics (cases in which the retentive clasp arms are visible).[7] To alleviate these drawbacks, the use of a small number of dental implants in conjunction with a removable partial denture can be an effective prosthodontic alternative.

Implants can be combined with an RPD in a number of ways. They can be used with a healing abutment to provide support to prostheses.[8,9] A precision attachment can also be fitted if extra retention is needed to support the rest of the retentive elements of the RPD.[10-16] Alternatively, implants can be used as abutments for a fixed prosthesis, either by supporting an RPD or as abutments to a telescopic crown RPD.[17-21]

The rationale behind the use of dental implants in conjunction with RPDs is to improve denture design by optimizing the distribution of abutments (teeth and implants). Since there is no rigid connection between implants and natural teeth, complications—such as intrusion of teeth and peri-implant bone loss, which often occur when connecting teeth with implants—are avoided.[21-23]

The aim of this study was to review the current literature concerning implant-assisted RPDs and to present the existing knowledge about critical aspects of this treatment.

Materials and methods

For the review, an electronic search was conducted on the PubMed database for published English-language articles that contained information about implant-assisted RPDs. All titles revealed by this strategy were retrieved in abstract form to determine their relevance to the researched subject. An initial scanning of the abstracts was performed to discard irrelevant publications, and the rest were obtained in full-text form. The electronic search was completed by an additional search of the reference lists in the selected full-text articles.

Established criteria had to be met in order for an article to be included in this review: the study must be published in an English-language, peer-reviewed journal; the study must be in vivo, regardless of the level of evidence, ranging from randomized controlled trials to case reports; and it must report on the rehabilitation of a partially edentulous maxilla or mandible with an RPD in conjunction with at least 1 dental implant associated with the removable prosthesis.

No restriction was applied concerning the follow-up period of the study, and all relevant papers were considered regardless of the year of publication. In addition, selected in vitro studies were also included, since they provided information on critical aspects of this treatment modality.

Results

A total of 512 studies were identified through the electronic PubMed search. After the initial scanning of the titles and abstracts, 482 articles were discarded, and 30 were retrieved in full form. Another 7 articles were retrieved after the search of the reference lists of the retrieved articles. A total of 37 articles were thus included in this review. All of the included studies had weaknesses in their level of evidence. There were 4 reviews of the literature, 7 in

vitro studies, 19 case reports, 5 retrospective studies, 1 randomized control trial, and 1 randomized crossover study. No statistical analysis of data was performed due to the different study designs of the selected studies.

Implant survival rate

Bortolini et al reported a 3.75% implant survival rate in an 8-year follow-up study involving 32 patients for whom 64 implants had been placed in association with RPDs.[24] Mijiritsky et al placed 33 implants in 15 partially edentulous patients, each of whom had an RPD.[25] The authors reported that all of the implants, as well as the prosthodontic devices, functioned successfully throughout a 2-7 year follow-up.[25] Mitrani et al treated 10 partially edentulous patients with 16 implants and RPDs.[7] The authors reported that no implant was lost during a follow-up period of 1-4 years.[7] Grossmann et al reported that 2 of the 67 implants inserted in 35 partially edentulous patients who received an RPD failed (97.1% survival rate) during a follow-up period of 9 months to 10 years.[26] In another study, 23 partially edentulous patients were treated with RPDs and a total of 44 implants.[27] The overall implant survival rate was 95.5% (2 implants failed). The mean follow-up time from implant placement was 31.5 months. Kaufmann et al reported that out of a total of 93 implants originally placed in 60 partially edentulous patients treated with RPDs, 3 were lost during a follow-up period of 12 months to 8 years, resulting in a 96.7% survival rate.[28] Krennmair et al treated 22 patients with maxillary RPDs retained by telescopic crowns that were supported by a combination of natural teeth and 60 dental implants in total.[21] After a mean of 38 months (range 12-108 months), no implant was lost. Payne at al reported a 100% survival rate for 24 implants used to treat 12 patients with implant-assisted RPDs during a 12-month follow-up.[29] Mijritsky presented the results of a 5-year follow-up study of 21 patients treated with implant-assisted RPDs, and the survival rate of implants, teeth, and prostheses was 100%.[30] No tooth decay or mobility was found, and the survival rate of the prosthetic components was 74%.[30]

Complications and maintenance

Krennmair et al reported 3 cases of screw loosening out of a total of 60 abutments used in 22 patients.[21] Matrix activation was necessary in 2 cases, and 4 patients needed denture margin adaptation. The periodontal parameters, stability, and pocket depth of the abutment teeth showed no significant differences between the initial and follow-up measurements. No cases of tooth loss, intrusion, tooth fracture, or endodontic treatment were noted, although tooth fracture occurred in 3 cases.[21] Kaufmann et al reported a 100% denture survival rate after 12 months to 8 years of service, noting that complications were mainly related to the tightening and replacement of matrices when anchorage systems were used.[28] Of the 60 patients who participated in the study, the authors noted a total of 8 cases of mucosal inflammation around implants, 1 case of hyperplasia, and 1 case that needed treatment with bone graft, along with 8 cases of tooth caries, 3 cases of periodontitis, and 2 cases of hyperplasia.[28] Mitrani et al observed pitting of the surface of the healing abutment in 2 patients out of 10, as well as 2 instances of abutment screw loosening.[7] There was also 1 mandibular denture case with a framework fracture that required refabrication of the prosthesis. Only 1 patient had severe inflammation that required surgical excision of the hyperplasic tissue.[7] Mijiritsky et al reported that during a 2-7 year follow-up period, prosthetic complications were minor with only 1 case of rupture.[25] No clinical signs of mobility or gingival inflammation around implants were noted.[25] Bortolini et al reported 2 cases of loose abutments and an average of 1 denture relining every 2.75 years for each patient.[24] The authors noted that the peri-implant soft tissues and marginal gingiva of most patients were slightly inflamed, and several edentulous ridges exhibited traumatic inflammation or small ulcers.[24] Payne et al observed that of their patients who had been wearing implant-assisted RPDs for 1 year, 58.3% were in need of prosthetic maintenance, such as matrix activation and/or adjustment of wrought wire clasps.[29] The authors also noted 1 case of acrylic denture base fracture.[29]

Prosthetic complications tend to occur more frequently during the first year of prostheses' function.[28] These complications tend to be readily alleviated by simple actions such as abutment screw tightening, replacement or polishing of the surface of the healing abutment, replacement of the resilient components of attachment systems, and/or matrix activation.

Patient satisfaction

Mitrani et al evaluated patient satisfaction using a questionnaire that allowed patients to grade the prostheses on a 5-point Likert scale from 1 (least favorable) to 5 (most favorable) prior to and after the insertion of an implant-assisted RPD.[7] All patients reported a dramatic increase (from 1.2 to 5) in satisfaction after the delivery of the new prosthesis.[7] Using a similar method, Bortolini et al found that the patients' satisfaction increased from 1.31 ± 0.43 to 4.59 ± 0.47 one year after treatment.[24]

In a study by Grossmann et al, 87% of patients that were rehabilitated with RPDs in conjunction with dental implants reported improved masticatory efficacy and 78% better aesthetics.[26] In addition, 65% of the patients graded their prostheses as "very comfortable," 22% as "comfortable," and 13% as "uncomfortable."[26] Mijiritsky et al mentioned that patients in their study reported good chewing ability and stability of their prosthetic devices without providing any additional data.[25]

In the study of Ohkubo et al, participants were asked to grade 2 treatment modalities (Kennedy class I with and without implant support as previously described) on 4 items (retention, comfort, chewing, and stability), using a 100 mm visual analogue scale (VAS).[31] The results showed that all patients rated the implant-associated RPD as superior to a conventional RPD for all 4 items. The VAS measurements showed significantly improved patient satisfaction when the implants were fitted.[31]

It should be kept in mind, however, that the patients included in the aforementioned studies were seeking care because they were dissatisfied with their previous dental condition. Thus, the patient satisfaction recorded with implant-assisted RPDs may be overstated.

Guidelines for implant placement

Most authors of the selected articles advised that implants should be placed as distally as possible, especially when free-end arches in the mandible are restored.

Studies employing the Finite Element Method (FEM) provided some additional directions for optimum implant placement in mandibular free-end arches.

In a 2008 study by Cunha et al, the authors used FEM on a mandibular free-end model and found that approximating the implant to the terminal abutment improved the RPD stability on the vertical plane, positively affected the distribution of stresses on the supporting structures, and diminished the demand to the abutment tooth.[32] Placing the implant in the first molar site produced the greatest dislodgment tendency when compared to all other tested sites. When an implant was placed in the site of the second bicuspid, the supporting tooth was noticeably relieved of stress.[32]

Using FEM, Verri et al simulated a free-end mandible and confirmed that the safest choice is to use as large an implant as possible in a connection to an RPD.[33] The increased implant length decreased the displacement of the prosthesis and had a positive effect in stress distribution. Increasing the diameter of the implant improved the stress distribution, but not the displacement, of the prostheses. However, even implants with small dimensions (such as 3.75 x 7.00 mm length) improved stress distribution and did not induce any risk for the longevity of the prostheses when the implants were used as RPD supports.

De Freitas Santos et al advised the use of straight or slightly inclined implants in association with RPDs.[34] A 5 degree inclination exhibited a favorable stress distribution in the supporting structures; thus a small degree of implant inclination was not considered harmful. A 30 degree inclination was discouraged, since it did not decrease the displacement of the prostheses.[34]

Pellizzer et al concluded that the use of healing abutments and ERA and O-ring retentive elements are all viable solutions when used in implants associated with RPD.[35] The use of the ERA retention system proved the most favorable in terms of stress distribution. On the other hand, the use of a single implant crown as a distal abutment in free-end RPDs seemed to be a nonviable solution since it presented higher displacement values than the other treatment modalities and higher concentrations of stress in the cortical and trabecular bone.[35]

Cunha et al studied the influence of mandibular residual ridge inclination and implant location.[36] According to their results, the distally descending ridge represents the most favorable morphology while the distally ascending ridge proved to be the worst of all by comparison.[36]

Discussion

The extent and quality of documentation found in the literature regarding RPDs used in conjunction with dental implants is inferior compared to the strong evidence that supports common implant prosthetic protocols.

Weak as it may presently be, the evidence found in the literature is encouraging. RPDs in conjunction with dental implants appear to be a viable alternative to the rehabilitation of partially edentulous patients. Most of the reviewed articles agreed that an implant-supported RPD offers a high level of patient satisfaction, due in part to it being a relatively affordable solution that is versatile and highly customizable.

The main indication described in the literature is the restoration of Kennedy Class I or II partially edentulous dental arches.[9,11,13,15,16] With the use of implants, these cases are converted to a more favorable Kennedy Class III situation.

A common problem associated with the mandibular bilateral distal extension RPD opposing a maxillary complete denture is known as the *Combination* (or *Kelly*) *Syndrome*, which is a result of the lack of a stable occlusion. A posterior implant, offering distal support to the RPD base, might prevent the development of Combination Syndrome manifestations.[7,30]

RPDs can also be used to handle implant failures of fixed restoration treatment plans. When the number of remaining implants that are originally placed in order to support a fixed prosthesis does not suffice to proceed with the initial treatment plan, and if additional surgery for the replacement of lost implants is not advisable, an RPD associated with the remaining implants can be an effective alternative.

RPDs can be used as interim restorations for staged implant placement; they are a cost-effective prosthodontic solution, as patients can reportedly save >50% on treatment costs when implant-assisted RPDs are chosen over implant-supported fixed restorations.[10,25,37]

RPDs in conjunction with dental implants offer many advantages over conventional RPDs. One benefit is the implants acting as posterior stops that inhibit the movement of the denture base toward the soft tissue under loading and thus contribute to a more stable occlusion. In an in vitro experiment, Ohkubo et al installed 5 pressure sensors in a model simulating a mandibular bilateral distal extension arch.[38] Implants were placed at the bilateral second molar areas, and a distal extension RPD was fabricated to fit the models. Loads were applied to the denture, and the pressure and displacement of the RPD were recorded and analyzed. The results showed that the implant support prevented the displacement of the distal extension RPD and decreased the pressure on soft tissues, which would theoretically improve the patient's comfort.[38]

Maeda et al constructed a 2-dimensional finite element model of a mandibular bilateral distal extension arch with only anterior teeth remaining.[39] Posterior occlusal support was provided by an RPD with or without implant support. Stress levels on the glenoid fossa were calculated when clenching force was applied. The results showed that the stress increase in the glenoid fossa with the implant-assisted RPD was approximately 20%-45% of that recorded for a conventional RPD. The authors concluded that a single implant placed underneath a distal extension RPD provides a stable occlusion, which might prevent bone remodeling in the temporomandibular joint.[39]

Implants used in conjunction with RPDs can drastically improve a patient's chewing ability.[31] In an interesting experiment, Ohkubo et al compared RPD function with and without distal implant support in 5 Kennedy class I patients.[31] The results showed that implant-assisted RPDs provided significantly greater bite force and a greater area of contact points than conventional RPDs. The authors concluded that a small number of implants can improve the stability and chewing provided by conventional distal extension RPDs.[31]

Bone is preserved around the site of implant placement as a result of remodeling stimulation, and the residual ridge resorption is expected to be minimal, since the stress transmitted to the underlying bone from the denture base is partly

absorbed by the implants.[10,25,30,39,40] Thus the need for frequent relining of the denture is eliminated. As mentioned previously, Kaufmann et al reported that after a follow-up period of 12 months to 8 years, 60 partially edentulous patients treated with RPDs and 93 implants presented a mean change in crestal bone height at the mesial and distal implant sites of -0.94 ± 1.3 mm in the maxilla and -0.52 ± 0.9 mm in the mandible.[28] No measurable changes were detected at 27 implant sites.[28] Krennmair et al reported 2.2 ± 1.0 mm marginal bone resorption around 60 dental implants used to treat 22 patients with maxillary RPDs after a mean of 38 months.[21] Mitrani el al measured the marginal bone loss in the mesial and distal surfaces of implants in patients whose implants were used only as vertical stops and in patients in whom resilient attachments were used for retention.[7] One year after placement of the prostheses, the mean bone loss for the first group was 0.32 ± 0.47 mm on the mesial implant surface and 0.44 ± 0.45 mm on the distal surface, while the second group's bone resorption almost doubled (0.93 ± 0.64 mm and 0.88 ± 0.34 mm for the mesial and distal surfaces, respectively). However, the differences between the groups were not statistically significant.[7]

The disadvantages of these type of prostheses included increased cost compared to conventional partial dentures, the need to perform surgery in order to place implants, and a more complicated clinical and laboratory construction protocol when compared to conventional RPDs.

The specific needs of each patient must be carefully evaluated. While the majority of the partially edentulous individuals in these studies opted for fixed prostheses, many of them did not meet the criteria for such a restoration. Various anatomical, medical, financial, or personal factors did not permit the placement of the implants necessary for an implant-supported fixed prosthesis. In such cases, a RPD is the common alternative. However, due to their inherent limitations, RPDs often do not fully satisfy their wearers. A small number of implants, strategically placed, may alleviate many of the problems linked with conventional RPDs and effectively contribute to patient satisfaction. It is nonetheless imperative that the advantages of the implant-assisted RPD are properly stressed to the patient. Since the final device is a removable denture, many partially edentulous individuals do not fully understand the benefit of the implant use and may hesitate to pay the extra cost. For these patients, a conventional RPD can be manufactured, and if the patient experiences retention or stability problems after the delivery of the restoration, implants can be placed, and the existing dentures can be adapted to them.

RPDs associated with implants can be considered as an intermediate prosthodontic solution between a conventional RPD and a fixed implant-supported restoration. They can be modified towards either of these 2 directions: they can be converted to a conventional RPD in case of failure of the implants, or they can be replaced by an implant-supported fixed partial denture by placing additional implants. It is therefore a highly versatile type of restoration that does not alter the patient's dental condition in an irreversible manner.

Conclusion

Taking the above under consideration, it can be concluded that implant-assisted RPDs represent a cost-efficient protocol, which should be considered when planning prosthodontic treatment. Clinicians can take advantage of the versatility and variety of prosthetic solutions available but must apply the procedures with caution, because at present, the existing scientific data are limited. Well designed studies with high levels of evidence are needed to provide robust evidence on critical issues such as design guidelines and long-term survival of implants associated with RPDs as well as patient acceptance and satisfaction in order to confirm the safety and predictability of this treatment modality so that it can be considered part of routine prosthodontics rehabilitation.

Author information

Dr. Chatzivasileiou is a doctoral candidate, Department of Removable Prosthodontics, Dental School, Aristotle University of Thessaloniki, Greece, where Dr. Kotsiomiti is an associate professor, and Dr. Emmanouil is an assistant professor.

References

1. Centers for Disease Control and Prevention. National Center for Health Statistics. *Trends in Oral Health Status: United States, 1988-1994 and 1999-2004.* Available at: http://www.cdc.gov/nchs/data/series/sr_11/sr11_248.pdf. Accessed January 7, 2015.
2. National Health Service. The Health and Social Care Information Centre. *Executive Summary: Adult Dental Health Survey 2009.* Available at: http://www.hscic.gov.uk/catalogue/PUB01086/adul-dent-heal-surv-summ-them-exec-2009-rep2.pdf. Accessed January 7, 2015.
3. Douglass CW, Watson AJ. Future needs for fixed and removable partial dentures in the United States. *J Prosthet Dent.* 2002;87(1):9-14.
4. Parein AM, Eckert SE, Wollan PC, Keller EE. Implant reconstruction in the posterior mandible: a long-term retrospective study. *J Prosthet Dent.* 1997;78(1):34-42.
5. Becker W, Becker BE, Alsuwyed A, Al-Mubarak S. Long-term evaluation of 282 implants in maxillary and mandibular molar positions: a retrospective study. *J Periodontol.* 1999;70(8):896-901.
6. Bahat O. Branemark system implants in the posterior maxilla: clinical study of 660 implants followed for 5 to 12 years. *Int J Oral Maxillofac Implants.* 2000;15(5):646-653.
7. Mitrani R, Brudvik J, Phillips KM. Posterior implants for distal extension removable prostheses: a retrospective study. *Int J Periodontics Restorative Dent.* 2003;23(4):353-359.
8. Jivral SA, Chee WL. Use of a removable partial denture in the management of chronic screw loosening. *J Prosthet Dent.* 2005;93(1):13-16.
9. Halterman SM, Rivers JA, Keith JD, Nelson DR. Implant support for removable partial overdentures: a case report. *Implant Dent.* 1999;8(1):74-78.
10. Senna PM, da Silva-Neto JP, Sanchez-Ayala A, Sotto-Maior BS. Implants to improve removable partial denture retention. *Dent Today.* 2011;30(2):118,120-121; quiz 121,113.
11. Giffin KM. Solving the distal extension removable partial denture dilemma: a clinical report. *J Prosthet Dent.* 1996;76(4):347-349.
12. Asvanund CA, Morgano SM. Restoration of unfavorably positioned implants for a partially edentulous patient by using an overdenture retained with a milled bar and attachments: a clinical report. *J Prosthet Dent.* 2004;91(1):6-10.
13. Kuzmanovic DV, Payne AG, Purton DG. Distal implants to modify the Kennedy classifications of a removable partial denture: a clinical report. *J Prosthet Dent.* 2004;92(1):8-11.
14. de Carvalho WR, Barboza EP, Caula AL. Implant-retained removable prosthesis with ball attachments in partially edentulous maxilla. *Implant Dent.* 2001;10(4):280-284.
15. Turkyilmaz I. Use of distal implants to support and increase retention of a removable partial denture: a case report. *J Can Dent Assoc.* 2009;75(9):655-658.
16. Uludag B, Clik G. Fabrication of a maxillary implant-supported removable partial denture: a clinical report. *J Prosthet Dent.* 2006;95(1):19-21.
17. Starr NL. The distal extension case: an alternative restorative design for implant prosthetics. *Int J Periodont Restorative Dent.* 2001;21(1):61-67.
18. Pellecchia M, Pellecchia R, Emtiaz S. Distal extension mandibular removable partial denture connected to an anterior fixed implant-supported prosthesis: a clinical report. *J Prosthet Dent.* 2000;83(6):607-612.
19. Jang Y, Emtiaz S, Tarnow DR. Single implant-supported crown used as an abutment for removable cast

partial denture: a case report. *Implant Dent.* 1998; 7(3):199-204.
20. Chronopoulos V, Sarafianou A, Kourtis S. The use of dental implants in combination with removable partial dentures: a case report. *J Esthet Restor Dent.* 2008; 20(6):355-364.
21. Krennmair G, Krainhofner 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(6):617-622.
22. Schlumberger TL, Bowley JF, Maze GI. Intrusion phenomenon in combination tooth-implant restoration: a review of the literature. *J Prosthet Dent.* 1998;80(2):199-203.
23. Baron M, Haas R, Baron W, Mailath-Pokorny G. Periimplant bone loss as a function of tooth-implant distance. *Int J Prosthodont.* 2005;18(5):427-433.
24. Bortolini S, Natali A, Franchi M, Coggiola A, Consolo U. Implant-retained removable partial dentures: an 8-year retrospective study. *J Prosthodont.* 2011;20(3): 168-172.
25. 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(10):744-746, 748, 750 passim.
26. Grossmann Y, Nissan J, Levin L. Clinical effectiveness of implant-supported removable partial dentures: a review of the literature and retrospective case evaluation. *J Oral Maxillofac Surg.* 2009;67(9):1941-1946.
27. Grossmann Y, Levin L, Sadan A. A retrospective case series of implants used to restore partially edentulous patients with implant-supported removable partial dentures: 31-month mean follow-up results. *Quintessence Int.* 2008;39(8):665-671.
28. 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(3):233-241.
29. Payne AG, Kuzmanovic DV, De Silav-Kumara R, van Staden IP. Mandibular removable partial dentures supported by implants: one-year prosthodontic outcomes. *J Dent Res.* 2006;85:2570.
30. Mijiritsky E. Implants in conjunction with removable partial dentures: a literature review. *Implant Dent.* 2007;16(2):146-154.
31. Ohkubo C, Kobayashi M, Suzuki Y, Hosoi T. Effect of implant support on distal-extension removable partial dentures: in vivo assessment. *Int J Oral Maxillofac Implants.* 2008;23(6):1095-1101.
32. Cunha LD, Pellizzer EP, Verri FR, Pereira JA. Evaluation of the influence of location of osseointegrated implants associated with mandibular removable partial dentures. *Implant Dent.* 2008;17(3):278-287.
33. Verri FR, Pellizzer EP, Rocha EP, Pereira JA. Influence of length and diameter of implants associated with distal extension removable partial dentures. *Implant Dent.* 2007;16(3):270-280.
34. de Freitas Santos CM, Pellizzer EP, Verri FR, de Moraes SL, Falcon-Antenucci RM. Influence of implant inclination associated with mandibular class I removable partial denture. *J Craniofac Surg.* 2011;22(2): 663-668.
35. Pellizzer EP, Verri FR, Falcon-Antenucci RM, Goiato MC, Gennari Filho H. Evaluation of different retention systems on a distal extension removable partial denture associated with an osseointegrated implant. *J Craniofac Surg.* 2010;21(3):727-734.
36. Cunha LD, Pellizzer EP, Verri FR, Falcon-Antenucci RM, Goiato MC. Influence of ridge inclination and implant localization on the association of mandibular Kennedy class I removable partial denture. *J Craniofac Surg.* 2011;22(3):871-875.
37. Chikunov I, Doan P, Vahidi F. Implant-retained partial overdenture with resilient attachments. *J Prosthodont.* 2008;17(2):141-148.
38. Ohkubo C, Kurihara D, Shimpo H, Suzuki Y, Kokubo Y, Hosoi T. Effect of implant support on distal extension removable partial dentures: in vitro assessment. *J Oral Rehabil.* 2007;34(1):52-56.
39. Maeda Y, Sogo M, Tsutsumi S. Efficacy of a posterior implant support for extra shortened dental arches: a biomechanical model analysis. *J Oral Rehabil.* 2005; 32(9):656-660.
40. Keltjens HM, Kayser AF, Hertel R, Battistuzzi PG. Distal extension removable partial dentures supported by implants and residual teeth: considerations and case reports. *Int J Oral Maxillofac Implants.* 1993;8(2):208-213.