

CLINICAL SCIENCE

Replacement of missing posterior tooth with off-center placed single implant: Long-term follow-up outcomes



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The restoration of a single missing molar is necessary to restore the occlusal plane and to prevent tooth movement and opposing tooth over-eruption. It also increases the total food platform, thus improving the masticatory performance.¹ In one study, the replacement of the second molar with an implant-supported restoration significantly enhanced masticatory performance and efficiency.²

Bragger et al³ compared the options of single-implant crown and 3-unit partial fixed dental prosthesis and demonstrated that the single-implant crown option was more cost-effective. Published data have shown that the single-tooth implant is a predictable prosthetic option with a survival rate between 94.4% and 99%.⁴⁻⁸ Becker and Becker⁹ were the first to report on the cumulative survival rates of posterior single-tooth implants with a stated value of 95%. In a 10-year follow-up study, Misch et al¹⁰ reported a survival rate of 98.9%. Salinas and Eckert¹¹ reported a prosthetic success rate of 95.1% in a meta-analysis.

ABSTRACT

Statement of problem. The distal offset placement of a single implant to replace a single tooth would overcome the shortcomings of the placement of a single wide implant in the posterior region. However, long-term evaluation is still-lacking.

Purpose. The purpose of this study was to evaluate the long-term outcomes of patients treated with a single tooth restoration supported by a distal-offset placed implant.

Material and methods. Thirty-one patients with a single restoration supported by an off-center placed implant were evaluated. The patients' demographic data were described. The known implant length was used as a reference to calibrate the linear measurements on digital periapical radiographs. Implant details, survival, and prosthetic complications were analyzed. The implant survival rate was analyzed with the Kaplan-Meier method.

Results. Thirty-four implants were placed with a distal offset to support single-tooth restorations. Twenty patients were women, and patient age was 56 ± 12 years. The implants had a follow-up time from loading up to 10 years (average: 4 ± 3 years). Most of the implants were inserted in type II bone, and 85% were placed in the molar region. The distal offset placement of the implant and the selection of a wide-diameter implant resulted in a mesial bone loss of 0.85 ± 0.57 mm and distal bone loss of 0.83 ± 0.68 mm. One implant failed after 4 months from insertion, resulting in a cumulative survival rate of 97.1%. No prosthetic complications were registered.

Conclusions. The distal offset placement of an implant is an efficient option for restoring a single missing posterior tooth when mesiodistal space is limited. (*J Prosthet Dent* 2015;114:27-33)

For a single crown, the occlusion should be designed to minimize the occlusal forces and to maximize force distribution to adjacent natural teeth.¹²⁻¹⁴ This is especially important when the missing molar is to be restored with an implant-supported prosthesis.^{15,16} For that, the placement of a single wide-diameter implant or 2 implants to support a single crown have been described.¹⁷⁻¹⁹

Several studies have reported increased failure rates when a wide-diameter implant is placed.^{17,20-24} This

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Clinical Implications

The off-center placement of the dental implant to restore a missing posterior tooth is a reliable option when limited mesiodistal space is available.

higher failure rate has been related to poor bone quality and quantity, high occlusal stress, inadequate primary stability, and trauma to the cortical bone during drilling.^{22,24,25} Implant fracture has been reported when hollow-body implants have been placed.²⁶ However, additional studies have reported high success rates for wide-diameter implants and have supported their use for restoring missing molars.^{19,27-31} Primary stability and an increased surface for osseointegration (roughened surfaces) are prerequisites for implant success.²⁹ Moreover, the use of wider implants avoids mesiodistal overcontouring of the crown and permits the achievement of a more natural emergence profile and reduced food impaction.^{29,32-35}

Bahat and Handelsman¹⁷ used 2 implants to support a single crown for restoring missing molars. One versus 2 implants have been compared to support a single crown in the molar area.³⁶ The authors documented a decrease in screw loosening when the 2-implant option was adopted. The 2-implant option increases the anchorage surface and reduces the rotational forces.¹⁷

The average mesiodistal space available after molar tooth loss is 9 to 12 mm; however, the effective space available for implant placement is 3 mm or less. The 2-implant option would require at least 12.5 to 14 mm of interdental space.³⁷ Buser et al³⁸ reported that the required space to accommodate 2 implants would be 16 mm. An off-center single implant placement has been reported to restore a missing molar when the available space is not sufficient to accommodate 2 implants. This option would minimize some disadvantages associated with the placement of a single implant, for example, dimensional discrepancies between the implant and restoration with unfavorable contours, leading to poor esthetics and hygiene. A long-term evaluation of off-center placed implants in the posterior region is still needed to confirm the predictability of this configuration.

A biomechanical study, applying the finite element analysis method, modeled the behavior of an offset implant placement in comparison with a center-positioned implant for the replacement of single missing tooth.³⁹ The simulation was performed with a titanium abutment and a ceramic crown placed to restore the first molar. That study found that the maximum bone stress induced by the distal load (230 N) showed a progressive reduction as the distal implant offset increased in relation to its prosthesis. However, the mesial load (200 N) resulted in increasing maximum bone stress as the

distal implant offset increased.³⁹ Taking as a reference the maximum bone stress in a center-positioned implant, the authors then established the optimum distal offset of the implant as the one that results in the least maximum bone stress when distal and mesial loads are applied. The optimal implant distal offset has varied slightly as a function of implant diameter, being 0.44 (for a 4-mm-diameter implant), 0.46 (for a 4.5-mm-diameter implant), and 0.59 mm (for a 5-mm-diameter implant).³⁹

Implant diameter was more efficient in reducing the stress transmitted to the periimplant bone than was implant length.⁴⁰ The majority of stress is concentrated in the crestal bone regardless of implant design, and so increasing implant length cannot counterbalance the effect of crown length.^{41,42}

The purpose of this study was to report on the long-term outcomes of off-center implant placement to replace a single missing posterior tooth. The molar region is the site where high occlusal force is generated.⁴³ We hypothesized that the distal-offset placement of dental implants would not be a negative factor for marginal bone loss and implant survival. The patients were followed in order to report on the predictability of this prosthetic design in terms of implant survival and prosthetic complications.

MATERIAL AND METHODS

Patient records were reviewed by 2 dentists (A.M.F. and J.F.) to identify those who were eligible to participate in this retrospective study. No protocol approval was needed from an ethical committee because this study was retrospective and the evaluated medical device had already been approved for clinical use. The inclusion criteria consisted of the following parameters: at least 1 missing posterior tooth, a Kennedy class III edentulous space, a single crown restoration, and an off-center placement of the dental implant. Patients who failed to meet any of the inclusion criteria were excluded from the study.

Selected records were reviewed to obtain patient demographic data in order to describe their sex, age, and smoking habits. Surgical variables of bone type at the implant site and insertion torque were also obtained. The bone type was assessed on a preoperative cone-beam computed tomography (CT) scans with diagnostic software (BTI Scan II; BTI Biotechnology Institute).⁴⁴

After flap elevation, the bone was drilled at low speed (150 rpm) without irrigation.⁴⁵ The sequence of bone drills for the preparation of the implant recipient site was determined according to the bone type.⁴⁴ To measure the insertion torque, the dental implant (BTI Biotechnology Institute) was inserted with a surgical motor at a torque value of 25 Ncm and then continued manually to complete the implant placement. The final insertion torque

Table 1. Diameter and length of implants inserted to restore single missing tooth

Diameter (mm)	Length (mm)						Total
	7.5	8.5	10.0	11.0	11.5	13.0	
4.0	0	0	2	0	0	1	3
4.5	0	0	1	2	1	1	5
5.0	0	0	4	11	0	3	18
5.5	1	2	0	3	0	1	7
6.5	0	0	1	0	0	0	1
Total	1	2	8	16	1	6	34

was noted in the patient's record. The implant diameter, length, surgery (1-stage or 2-stage), loading time, and location were also analyzed.

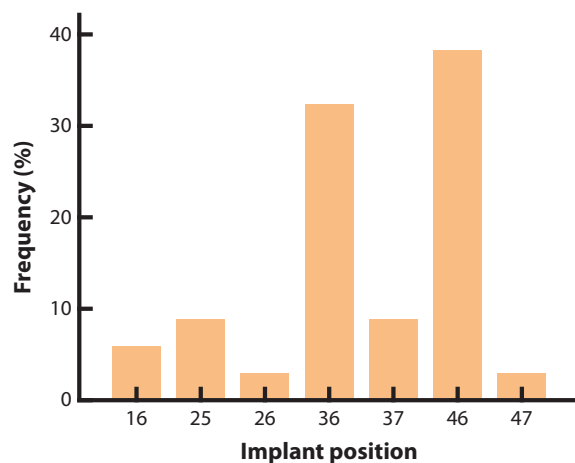
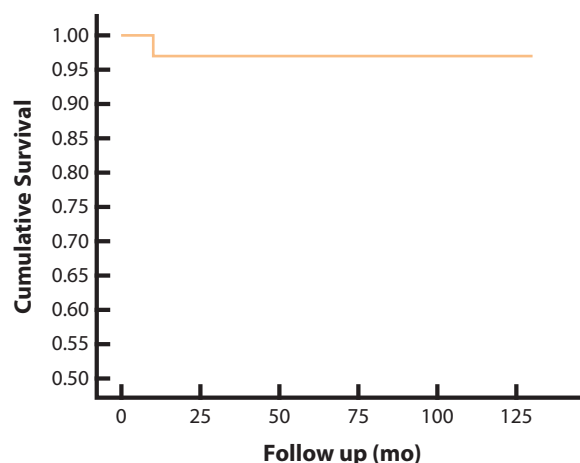
After implant insertion, a cover screw was placed when 2-stage implant surgery was planned. Otherwise, a healing cap was placed. The patients used no provisional prosthesis during healing. After 4 months of healing, an impression was made with polyether impression material (Impregum Penta; 3M ESPE) with the open-tray technique.⁴⁶ A titanium abutment was then selected according to the height of the soft tissue. At the laboratory, the technician trimmed the abutment (Bio-abutment; BTI Biotechnology Institute) to fabricate a metal ceramic structure. The abutment was then fixed to the implant with a gold screw placed at a torque of 30 to 35 Ncm. The metal ceramic prosthesis was then cemented.

From the follow-up records, the period of follow-up expressed in months was measured from insertion and loading. Implant survival, prosthetic complications, and marginal bone loss were assessed. Marginal bone loss (the distance between implant shoulder and first bone-implant contact) was measured on standardized periapical radiographs and expressed in millimeters. The known implant length was used as a reference to calibrate the linear measurements on the digital periapical radiograph.

The patient was the statistical unit for the description of sex, age, and smoking habits. Mean, standard deviations, and range were calculated for the age variable, and relative frequency was calculated for the other patient-related variables. The implant was the statistical unit for the statistical description of bone type, insertion torque, implant diameter, length, implant surgery, loading time, location, follow-up times, implant survival, prosthetic complications, and marginal bone loss. The implant survival as a function of time was analyzed with Kaplan-Meier method. All the statistical analyses were performed with a statistical software package (SPSS for Windows v15.0; IBM Corp).

RESULTS

Thirty-one patients had 34 off-center placed implants to support a single-tooth restoration. Mean age was 56 ± 12

**Figure 1.** Distribution of dental implants placed to restore single missing posterior tooth.**Figure 2.** Implant survival rate.

years (range 38 to 86 years). Five patients smoked 4 or more cigarettes per day. Women represented 65% of the patients.

The analysis of the cone-beam CT scans revealed that type II bone was present at about 47% of the operated sites, type bone III at 18%, and type bone IV at 6%. This enabled implant insertion at a torque value of 49 ± 19 Ncm (range 10 to 80 Ncm). The mean torque value for the implants placed in the maxilla was 46 ± 16 Ncm and for those placed in the mandible was 49 ± 20 Ncm.

Implant dimensions are listed in Table 1. At least 76.4% of the implants had a diameter greater than or equal to 5 mm, and at least 91.1% had a length greater than or equal to 10 mm. Two-stage implant surgery was performed for 41% of the implants. Loading was within 6 months after insertion for 49% of the implants. The median of time to loading was 9 months in the maxilla and 6 months in the mandible.

The distribution of the placed implants is shown in Figure 1. Implants that restored a missing molar tooth

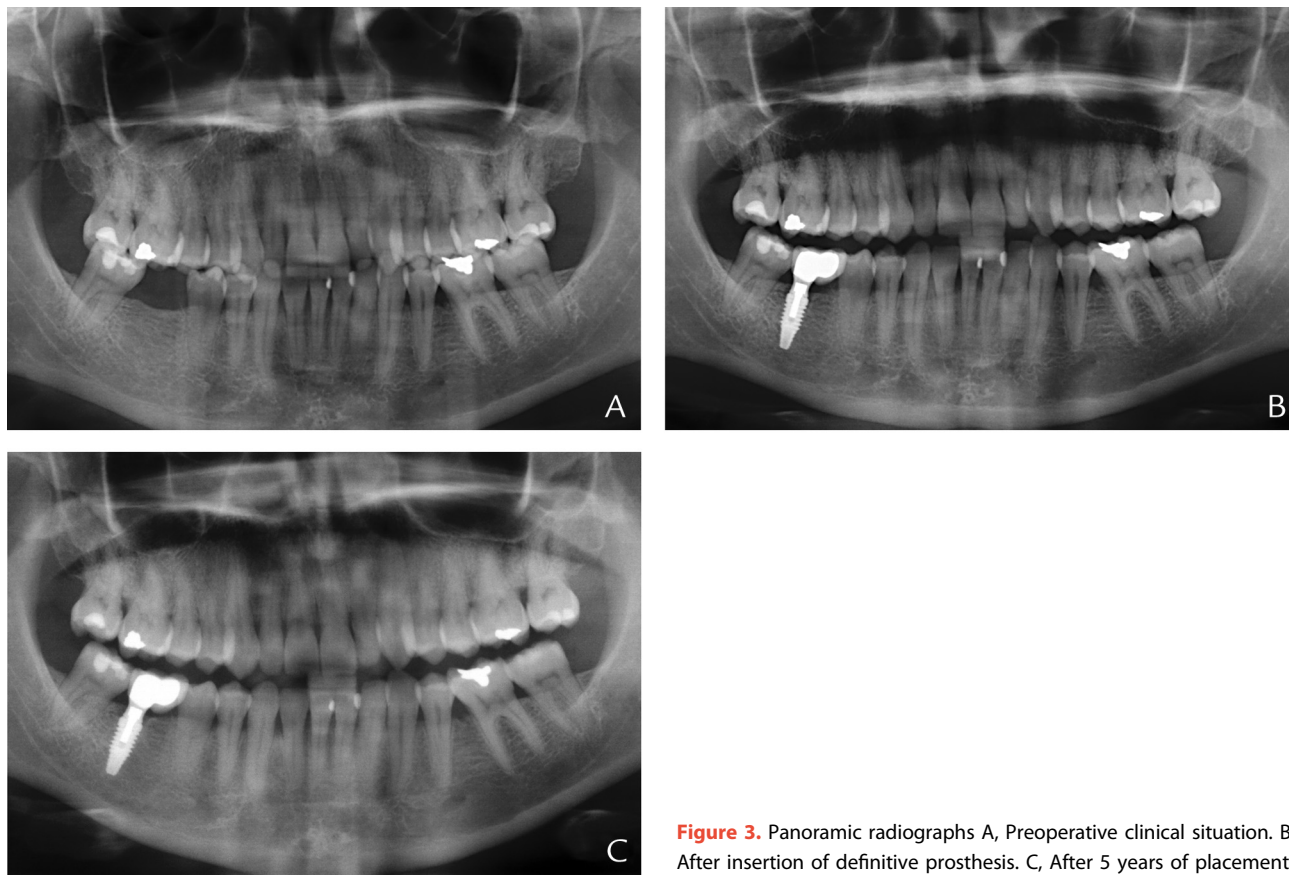


Figure 3. Panoramic radiographs A, Preoperative clinical situation. B, After insertion of definitive prosthesis. C, After 5 years of placement.

accounted for 85.3% of the analyzed implants. Twenty-eight implants were placed in the mandible.

The average follow-up time was 52 ± 34 months (range 4 to 129 months) after implant insertion and 44 ± 34 months (range 0 to 120 months) from implant loading. The follow-up time was between 1 and 3 years from loading for 29.6% of the implants, between 3 and 7 years for 48.2%, and more than 7 years for 22.2%. One implant failed 4 months after insertion. Thus, the implant survival rate was 97.1% (Fig. 2). Patients were screened for prosthetic complications (screw loosening or fracture, abutment or implant fracture, ceramic chipping, and prosthesis fracture), and the results indicated the absence of any complication (Fig. 3).

Data for marginal bone loss measured on periapical radiographs were available for 22 implants. The time span between implant loading and acquisition of the radiograph in which measurements were performed was 56 ± 30 months (range 12 to 120 months). The mesial and distal bone loss is shown in Figure 4. The mean mesial bone loss was 0.85 ± 0.57 mm (range 0 to 2.13 mm), and the mean distal bone loss was 0.83 ± 0.68 mm (range 0 to 2.20 mm). The mesial and distal bone loss was less than or equal to 1 mm for 73% of the analyzed dental implants. Only 2 implants had a mean bone loss greater

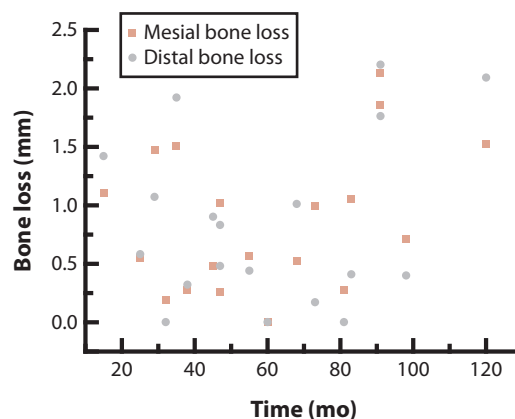


Figure 4. Marginal bone loss around distal offset implants as measured on periapical radiograph. Time variable was calculated by subtracting date of last periapical radiograph from date of implant loading.

than 2 mm. Figure 5 shows the status of soft tissue and marginal bone after 8 years of implant insertion. Figure 6 shows these results after 5 years of implant insertion.

DISCUSSION

The results of this study support the acceptance of the null hypothesis. Thus, the distal-offset placement of a

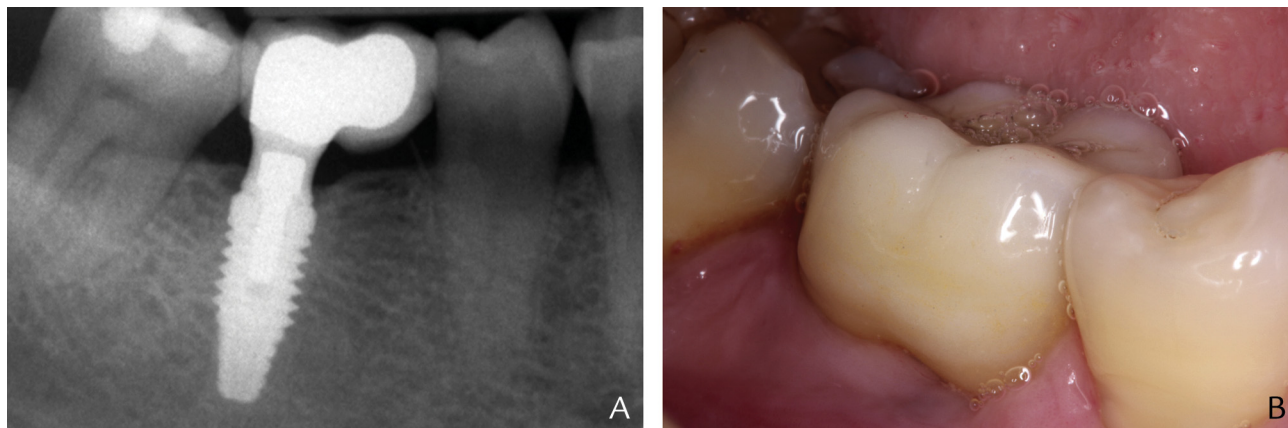


Figure 5. Periimplant hard and soft tissue status after 5 years of implant insertion.

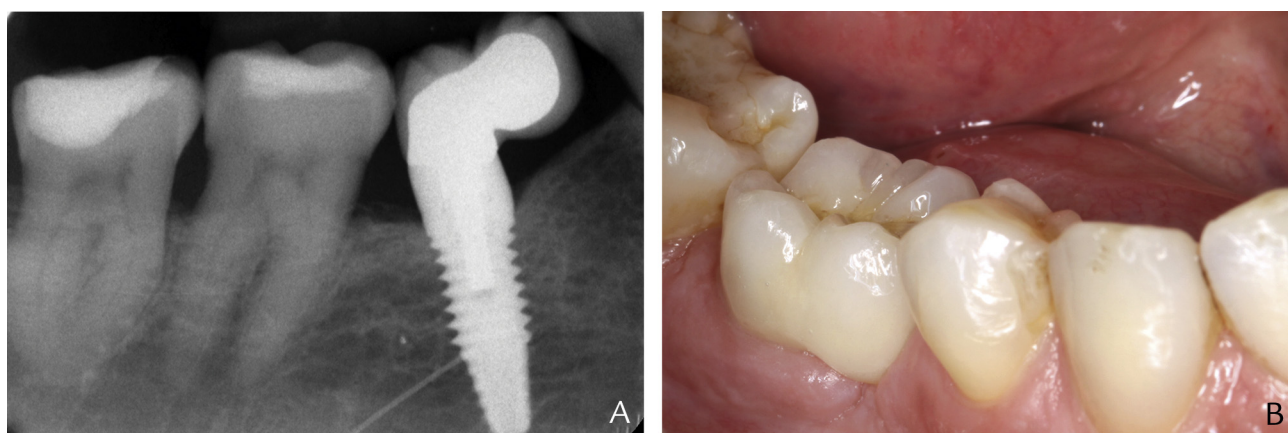


Figure 6. A, Status of periimplant bone. B, Soft tissue after 8 years of follow-up.

dental implant to restore single-tooth in the posterior region was not found to be a risk factor for marginal bone loss and implant survival. The distal offset placement of a single implant to restore a missing tooth has been effective in the restoration of an edentulous space of less than 14 mm in a mesiodistal direction.

In comparison with a center-positioned implant, finite element analysis has shown that the distal offset placement of a dental implant results in the least bone stress around the implant.³⁹ The bone stress is found to be concentrated in the crestal bone and is more efficiently reduced by increasing the implant diameter rather than implant length.⁴⁰⁻⁴²

Thus, the treatment plan followed in this study includes the distal offset placement of the implant and the selection of wide-diameter implants to minimize the stress transmitted to the supporting bone. In the posterior sector, this protocol avoids overloading and ensures the survival of the prosthesis. Occlusal forces are greatest in the molar region,⁴³ and thus restoration of missing molars with an implant-supported prosthesis will be more challenging. The absence of a periodontal ligament

around a dental implant will make it more vulnerable to eccentric or excessive occlusal loads.¹⁵ These types of forces will increase the stress at the implant-bone interface and may provoke bone resorption and implant loss. Moreover, they will increase the risk of prosthetic complications like screw loosening, implant or abutment fracture, chipping of the ceramic, and the fracture of the prosthesis.¹⁶

In this study, delayed implant loading has been performed. However, the high success rate of single-tooth implant restorations has encouraged the development of predictable protocols for immediate placement (after tooth extraction) and immediate restoration/loading.³²⁻³⁵ In a meta-analysis, Atieh et al³¹ have reported a survival rate of 99% of immediately placed implants.³¹ In that study, immediate loading of single implants that were placed in healed molar sites resulted in a survival rate of 97.9%.

During the follow-up, only 1 early implant failure occurred, and the marginal bone loss was less than 1 mm for most of the dental implants. The implant survival rate (97.1%) of the off-center placed dental implants is

comparable with the survival rates reported for wide-diameter implants and for 2 narrow diameter implants placed to restore a single missing tooth.^{9-11,17-31,36}

It should be noted that the mesiodistal dimension of the edentulous area in these studies was not restricted.^{9-11,17-31,36} The high implant survival rate in the present study could be related to the quality of bone in which the implants were placed (mainly type II bone) and the achievement of adequate primary stability.^{29,32-35} The emergence profile and the embrasure design avoided over-contouring of the prosthesis. This permitted effective cleaning and avoided food impaction.²⁹ The low marginal bone loss indicates the adequate biomechanical behavior of the implant-prosthesis complex.

This study is limited by its retrospective design, sample size, and the absence of a control group. Further studies with a larger sample size and comparing loading protocols are necessary to establish sound conclusions about the use of distal offset implant placement to restore a missing single tooth in the molar region.

CONCLUSIONS

The effectiveness of a distal offset from a single implant for the restoration of a single missing posterior tooth was studied. The implant survival, marginal bone loss, and prosthetic complications were analyzed for implants with a follow-up time from loading to approximately 10 years, with an average of 4 years. The results of this study demonstrate that offset implant placement is effective in restoring a single missing posterior tooth with limited mesiodistal space (implant survival rate was 97.1% and average marginal bone loss was less than 1 mm).

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Noteworthy Abstracts of the Current Literature

Various cements and their effects on bond strength of zirconia ceramic to enamel and dentin

Prylinska-Czyzewska A, Piotrowski P, Prylinski M, Dorocka-Bobkowska B
Int J Prosthodont 2015;28:279-81

Zirconia ceramic disks (Cercon) were fabricated using a computer-aided design/computer-assisted manufacture system and fitted to hard tooth tissues from freshly extracted bovine mandibular incisors using seven cements (zinc phosphate, zinc polycarboxylate, Eco-Link, Panavia F 2.0, Clearfil SA Cement, MaxCem Elite, and GC Fuji Plus) with various physicochemical and bonding properties. Bond strengths were determined using a universal testing machine (Hounsfield H5KS) with a 5,000-N head and a cutting knife speed of 0.5 mm per minute. The study showed that the strongest bond between zirconia ceramic and hard tooth tissues was obtained with Panavia F 2.0 adhesive cement based on 10 methacryloyloxydecyl dihydrogen phosphate monomer.

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