

Use of Sintered Porous-Surfaced Dental Implants to Restore Single Teeth in the Maxilla: A 7- to 9-Year Follow-up



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This report from a prospective study discusses the status of a group of 20 single maxillary sintered porous-surfaced (SPS) dental implants after 7 to 9 years in function restored with screw-retained crowns. Twenty patients each received a single SPS implant placed in a two-stage surgical approach; 65% replaced premolar or molar teeth, while the remainder replaced anterior teeth. Patients were examined annually. Standardized radiographs were used to assess peri-implant crestal bone levels and to determine an implant success rate. Jemt Papilla Index scores were used to assess the extent of papilla reformation between each implant and its two contiguous teeth. After 7 to 9 years, 17 implants were available for assessment (one patient had died, and two patients had moved away). One implant was removed after the 9-year visit because of progressive bone loss, giving a survival rate of 92.9%. The failure of this implant was related to deficiency in initial alveolar ridge width with loss of the remaining thin buccal cortical plate. With the exception of the failed implant, no significant changes in mean annual crestal bone loss were noted from years 1 to 9, giving a similar success rate (92.9%). Jemt Papilla Index scores of 2 or 3 were assigned for the majority of papillae. SPS implants can be used effectively to replace single missing maxillary teeth. (Int J Periodontics Restorative Dent 2009;29:191-199.)

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The use of dental implants to replace single teeth has become the treatment of choice in many patients.¹⁻³ A variety of implant designs, generally with a threaded geometry, have been used.¹⁻¹³ Advantages relative to traditional tooth-supported fixed prostheses include less invasive treatment, easier esthetically driven replacement of the prosthesis, and cost effectiveness,^{14,15} although care must be given to maintaining adequate distance from contiguous teeth.¹⁶ This report presents an update of a group of single-tooth maxillary sites treated with sintered porous-surfaced (SPS) press-fit dental implants⁵ after 7 to 9 years in function.

Method and materials

Details of the study design have been previously reported.⁵ Twenty non-smoking, healthy adults (10 women, 10 men; mean age 43.5 years) each received a single maxillary SPS implant. The implants (Endopore; Innova Corporation) were made from titanium alloy (Ti-6Al-4V), had a sintered porous-surfaced press-fit design,¹⁷ and were

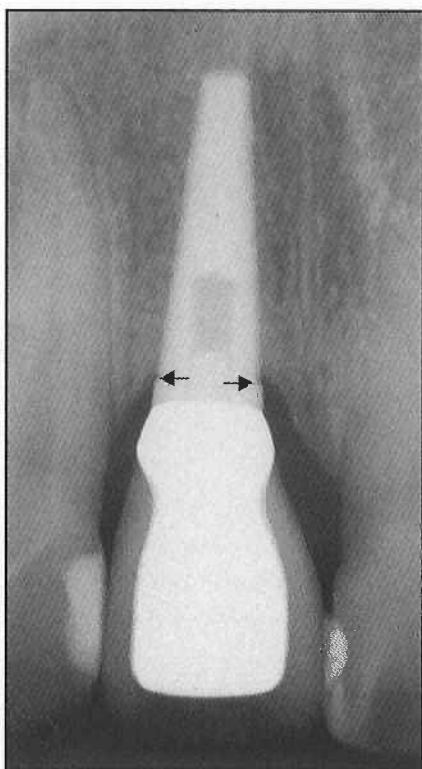
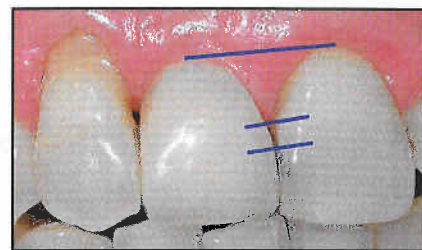


Fig 1 (left) Radiograph of a 12-mm-long implant replacing the maxillary right central incisor after 9 years in function. Arrows denote the junction between the 1-mm machined collar and the sintered surface segment of the implant.

Fig 2 (right) Clinical view of the crown restoring the implant shown in Fig 1. Computer-generated horizontal lines superimposed over the mesial papilla of this implant were used to facilitate the necessary soft tissue measurements.



either 4.1 mm in diameter and 9 or 12 mm in length or 3.5 mm in diameter and 9 mm in length. The most coronal 1 mm of the implants comprised a machined collar. Implants were placed using a submerged technique and osteotomy preparation with burs and/or hand osteotomes and were allowed to integrate for 4 months before re-entry. Restorations were screw-retained, nonsplinted, porcelain-fused-to-metal crowns prepared with the aid of either stock titanium alloy abutments or cast UCLA abutments,¹⁸ all of which had a hexed base to prevent rotation and screw loosening. One surgeon and one prosthodontist worked together to provide the prescribed treatment.

Baseline radiographs were collected 1 month after prosthesis

insertion. Subsequent radiographs were collected after 6 months, after 1 year, and again after 2, 3, 5, 7, and 9 years. All radiographs taken in the first 3 years were exposed using a customized stainless steel film holder attached directly to each implant after crown removal.⁵ However, because of concerns regarding possible stripping of internal threads and damage to the peri-implant mucosal seal via repeated removal and reinsertion of prostheses,¹⁹ after the third year, Rinn film holders (Rinn Corporation), customized for each patient, were used to expose radiographs. Both types of film holders permitted direct connection to the x-ray tube. Radiographic processing was performed using fresh chemicals. As in previous investigations,^{5,20-22} crestal bone levels in

radiographs were measured relative to the junction (MPS-jx) between the machined collar and the sintered surface region of the implant (Fig 1). Measurements on both mesial and distal aspects of each implant were recorded by a single radiologist from each radiograph. Measurement error was determined using a standard *t* test to compare duplicate measurements of a subsample of radiographs, where the second set of measurements was done 6 months after the first set.

The interproximal papillae were assessed at the most recent patient recall (7 to 9 years in function) using the Jemt Papilla Index (PI).²³ Intraoral photographs of implant restorations (Fig 2) and surrounding soft tissues were obtained using a Nikon Coolpix 4500 digital camera (Nikon Corporation).

However, these clinical photographs were used only if direct perpendicular access to the implant restoration could be achieved with the camera lens. Otherwise, digital photographs (Fuji Finepix S7000 camera, Fuji Photo Film Canada) were taken of the implant restoration as reproduced in study models made in Type III orthodontic stone from hydrocolloid impressions.

All photographs were examined using Adobe Photoshop software (version 5.1, Adobe Systems). This program allowed arbitrary horizontal lines to be drawn at the levels of the midfacial peri-implant gingival margin, the contact points between the implant crown and its mesial and distal tooth neighbors, and the height of papillae relative to the implant crown (Fig 2). Measurement of the distance between the contact points and the papillae tips, as well as between the midfacial gingival margins and the papillae tips, were assessed to quantify the amount of papillary tissue reformed in each embrasure space.

As stated, a Jemt Index²³ was calculated for each papilla and used to score papillary anatomy for each implant restoration both mesially and distally into one of four categories. A PI of 0 was given to embrasure spaces where no papilla had formed. A score of 1 was given to papillae that filled less than 50% of the embrasure space. Papillae that filled more than 50% of the embrasure space, but did not reach the contact point with the adjacent tooth, were scored as 2. A PI of 3 was given to any papilla that completely filled the interproximal embrasure space.

Both intraobserver and interobserver errors with the Jemt PI were determined. For intraobserver error, the principal author performed all measurements twice, with the second set made 1 week after the first. For interobserver error, a colleague not otherwise involved in the study applied the index at all the implants.

Statistical analyses

Mean values, standard deviations, and confidence intervals were calculated for all variables using descriptive statistics. Determination of the mean peri-implant bone loss for each time interval (1 to 3 years, 3 to 5 years, etc) was assessed by first calculating the change in peri-implant osseous crest level for each implant during that time period; these values were then used to determine the mean change for all implants assessed at each time period. Calculation of the mean annual change in peri-implant osseous crest levels from 1 to 9 years was determined by compilation of the mean change in recorded radiographic bone levels for all implants over the entire study period. Analysis of variance showed no statistically significant differences ($P > .05$) between mesial and distal measurement values. Life table analysis was used to determine the survival rate through the 9-year follow-up, and frequency distribution tables were used to present the percentage of implants displaying a specified amount of bone loss for each time interval over the 9-year period.

Results

A summary of implant sizes and arch positions for the 20 implants is shown in Fig 3. Seven (35%) were 4.1×12 mm, seven (35%) were 4.1×9 mm, and six (30%) were 3.5×9 mm ("mini implants"). Thirteen implants (65%) were placed in posterior regions (premolars or molars), while seven implants (35%) were placed anteriorly (incisors or canines) (Fig 3). There were few prosthetic complications. One anterior crown could not be removed at year 1 to attach the radiographic film holder and had to be cut off and replaced. Two years later, the retention screw for this crown had loosened and needed tightening. The screw loosened again at 7 years but was not a problem thereafter, and the implant has been in function for more than 9 years. One other retention screw was loose at 6 months after loading, but after tightening, no further problems arose. None of the other restorations showed prosthetic complications.

At the time of this report, 17 of the 20 study patients were available for evaluation. Of the three patients lost to follow-up (15%), one had died (after 3 years) and two had moved away (one after 4 years and one after 6 years). Of the 17 patients with current radiographs, all had passed 7 years of function, 14 had passed 8 years, and 9 had passed 9 years. One implant (4.1×12 mm) that had passed 9 years had shown progressive crestal bone loss beyond the MPS-jx for the previous 3 years and was classified as a failed implant. It was removed, giving a 9-year survival rate of 92.9% (Table 1). This failed implant had been placed in

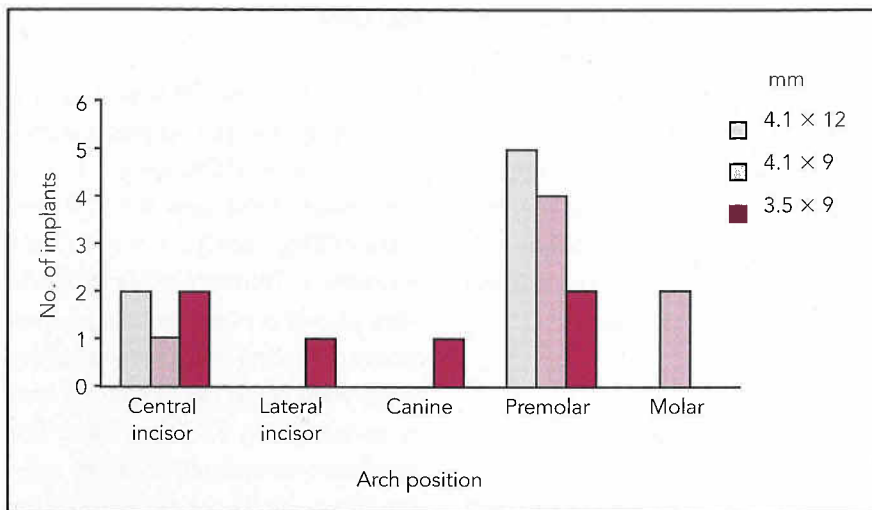


Fig 3 Implant sizes used and their positions in the maxilla.

Table 1 Life table analysis of implant survival

Time in function (mo)	No. of implants at start of interval	No. of implants lost to follow-up during interval	Implant failures	Implant failure rate (%)	Cumulative survival rate (%)
0-12	20	0	0	0	100
13-24	20	0	0	0	100
25-36	20	0	0	0	100
37-48	20	0	0	0	100
49-60	18	2*†	0	0	100
61-72	18	0	0	0	100
73-84	17	1†	0	0	100
85-96	17	0	0	0	100
96-108	14	0	1	7.1	92.9

*Patient death; †patient moved away.

a narrow ridge using osteotomes²⁴ and was left with a thin buccal plate of bone with no augmentative grafting. This was an error in judgment, since it is now known that buccal bone at implant sites should be at least 1.8 mm thick to prevent excessive loss secondary to the surgical insult of osteotomy preparation.²⁵

Radiographic data

Bone loss data generated from collected radiographs are shown in Table 2. Measurement error was insignificant (0.03 mm; $P = .28$). Analysis of variance showed no significant differences between mesial and distal bone loss measurements for any time interval ($P > .05$). Mean bone loss in relation to MPS-jx from baseline to 1 year was 0.37 mm, the largest recorded loss

during the study. The bone crest at 1 year had resorbed to a level of 0.37 mm apical to MPS-jx, ie, 1.37 mm apical to the implant-abutment connection (ie, microgap). In years 2 and 3, a mean bone height gain of 0.08 mm was seen, while from years 3 to 5, a mean loss of 0.01 mm was recorded. The time period from 5 to 7 years produced no detectable loss, while from 7 to 9 years a 0.16-mm mean loss of crestal bone height was noted. The

