Narrow- (3.0 mm) Versus Standard-Diameter (4.0 and 4.5 mm) Implants for Splinted Partial Fixed Restoration of Posterior Mandibular and Maxillary Jaws: A 5-Year Retrospective Cohort Study

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Background: Evidence concerning predictability of narrow-diameter implants (NDIs) (<3.3 mm) to restore partially edentulous posterior maxillary and mandibular areas is limited. The aim of this study is to compare the 5-year outcomes of NDIs (3.0 mm) and standard-diameter implants (SDIs) (4.0 to 4.5 mm) supporting fixed partial dentures (FPDs) in posterior mandibular and maxillary jaws.

Methods: All patients treated with at least two adjacent NDIs or SDIs according to available bone thickness and with a minimum follow-up of 5 years after placement were invited to undergo a clinical and radiologic examination. Outcome measures were implant and FPD failures, biologic and prosthetic complications, and marginal bone loss.

Results: A total of 107 out of 127 patients attended the examination: 49 (113 implants) of the NDI group, and 58 (126 implants) of the SDI group. Two NDIs failed in one patient versus four SDIs in four patients ($P = 0.37$). One FPD failed in the NDI group versus two FPDs in the SDI group ($P > 0.99$). Nine biologic complications occurred in the NDI group and twelve in the SDI group ($P = 0.81$). Twelve prosthetic complications occurred in the NDI group and only two in the SDI group ($P = 0.001$). Peri-implant marginal bone loss at 5 years was 0.95 ± 0.84 mm for the NDI group and 1.2 ± 0.86 mm for the SDI group ($P = 0.06$).

Conclusion: Five-year data indicate that FPD treatment in posterior mandibular and maxillary jaws with NDIs was as reliable as with SDIs, although NDIs showed a higher risk of prosthetic complications. *J Periodontol 2017;88:338-347.*

KEY WORDS

Dental implants; osseointegration; prosthodontics.

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Narrow-diameter implants (NDIs) (<3.3 mm)[1] are available from almost all implant manufacturers and are designed for specific clinical indications such as restricted interdental spaces, mandibular incisors, and maxillary lateral teeth.[2-6] Successful use of NDIs in these situations encouraged clinicians to expand their clinical application. In particular, NDIs may significantly reduce the need for bone grafting in horizontally atrophic posterior areas.[7,8] Use of NDIs would allow practitioners to overcome the disadvantages of bone augmentation procedures such as prolonged healing time, additional costs, and increased surgical morbidity.[9-11] However, caution in the use of NDIs has been advocated in these areas because of concern regarding the negative impact of loading NDIs, which have less osseointegration surface and an increased probability of fracture compared with standard-diameter implants (SDIs).[12] Furthermore, in vitro studies and finite element analyses have shown that stress values affecting the crestal cortical bone are reciprocal to the implant diameter, which means overloading of NDIs might lead to disadvantageous peri-implant crestal bone resorption, influencing longevity of the treatment

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outcome.[13,14] Although an increasing body of literature indicated that use of NDIs might not jeopardize stability of the peri-implant bone level in anterior single-tooth gaps,[2-6] very few studies have properly evaluated the modifications of marginal bone surrounding NDIs in partially edentulous load-bearing areas over time.[15,16] It may be that NDIs supporting a fixed partial denture (FPD) constitute a risk factor for progressive marginal bone resorption. Long-term observations addressing this finding for NDIs with a diameter of 3.0 mm are still missing.[17]

The aim of the present retrospective cohort study was to compare clinical and radiographic outcomes of FPDs supported by NDIs (3 mm) versus SDIs (4.0 or 4.5 mm) in posterior jaws after 5 years of follow-up. This study is reported following the STROBE (Strengthening the Reporting of Observational studies in Epidemiology) guidelines for reporting observational studies.[18]

MATERIALS AND METHODS

Patient Selection

The present study was designed as a pragmatic retrospective cohort study with two arms including consecutively treated patients. Medical records databases of two private dental practices were electronically reviewed to find potentially eligible patients. The following inclusion criteria were applied: 1) partially edentulous patients who received implants in posterior regions of the maxilla and mandible from January 2009 to July 2011; 2) patients with healthy or treated periodontal conditions; 3) healed edentulous ridge, at least 3 months from the time of extraction; 4) presence of an FPD supported by at least two adjacent NDIs (3.0 mm) or SDIs (3.5 to 4.0 mm) with a length varying from 11 to 15 mm; 5) presence of an opposing dentition (e.g., natural teeth, fixed prosthetic restorations on natural teeth or implants); 6) delayed implant loading; and 7) availability of a baseline radiograph taken on the day of implant placement. Patients were excluded if they: 1) had received horizontal bone augmentation procedures before implant placement; 2) were diagnosed with medical conditions known to alter bone metabolism after implant placement, such as cancer requiring chemotherapy or facial radiotherapy, intravenous aminobisphosphonates for metastatic bone diseases, uncontrolled diabetes mellitus, immunosuppression or immunodepression; and 3) abused alcohol (>10 g/day)[19] or tobacco (>20 cigarettes/day). Patients who presented wear facets, complained about muscle pains, or reported grinding during sleep were considered as bruxers.[20]

Of 127 patients (282 implants) selected for the study, 107 patients (239 implants) were available for data collection at the 5-year follow-up. Selected patients were divided into two cohorts according to whether they had received NDIs (narrow-diameter group: 11 males and 38 females, aged 44 to 81 years; mean age: 61.02 ± 9.76 years) or SDIs (standard-diameter group: 22 males and 36 females, aged 39 to 78 years; mean age: 56.77 ± 9.86 years) and were invited to participate in a 5-year follow-up clinical and radiographic examination. The study was approved by an institutional clinical/human experimentation panel (Ethics Committee of the Area Vasta Romagna and IRST, Meldola, Forlì-Cesena, Italy; authorization no. IMP2014) and performed in accordance with the principles stated in the Declaration of Helsinki, as revised in 2013. Each patient gave written informed consent to participate in the study.

Surgical and Prosthetic Procedures

All treatments were performed by two experienced operators (FP and EC), who followed the same clinical protocol during placement of the dental implants and prosthetic rehabilitation. Surgical procedures were performed under local anesthesia or local anesthesia with oral sedation (triazolam 0.25 mg). All patients were premedicated 1 hour preoperatively with 600 mg ibuprofen and 2 g amoxicillin plus clavulanic acid (875 + 125 mg) or 1 g clarithromycin if allergic to penicillin, and they also performed 1-minute rinses with 0.2% chlorhexidine digluconate before surgery. NDIs or SDIs[§] were placed in healed edentulous ridges according to the standard procedures as recommended by the manufacturer and with the smooth collar flush to the buccal alveolar crest. NDIs were used in areas with an alveolar width between 4.0 and 5.5 mm; SDIs were used when the width was >5.5 mm. The amount of available bone width was determined on preoperative computer tomography scans. The two-stage approach was completed after 3 to 4 months of submerged healing with surgical reentry and placement of appropriate healing abutments on the implants. After maturation of soft tissues, the definitive full-zirconia, zirconia-ceramic, metal-ceramic, and titanium-composite FPDs were delivered; they were either screw retained or cemented with provisional cement[‖] on customized computer-aided design/computer-assisted manufacture or prefabricated titanium abutments.

At the time of FPD delivery, static and dynamic occlusion was adjusted to ensure a flat occlusal plane and to achieve canine guidance or group-function occlusion without working or non-working interference during lateral movements. After FPD placement, patients entered a supportive periodontal maintenance protocol involving visits and full-mouth scaling every 6 to 12 months. At each follow-up visit home care

§ OsseoSpeed TX, Dentsply Implants, Mannheim, Germany.
‖ Temp-Bond, Kerr, Romulus, MI.

procedures were reinforced, and if necessary occlusal adjustments were made.

Outcome Measures

The clinical and radiographic examination at the 5-year follow-up appointment was conducted by two investigators (CF and EC) and included an update of the medical and dental history, full periodontal charting, a prosthodontic examination, and a periapical radiograph of all implants that fulfilled inclusion criteria.

Outcome measures evaluated in the present study were as follows.

FPD failure. A planned FPD that could not be placed due to implant failure(s), loss of the FPD secondary to implant failure(s), or any FPD that had to be replaced.

Implant failure. The presence of any mobility of the individual implant and/or any situation requiring implant removal, including implant fracture.

Biologic complications. Peri-implant mucositis (the presence of inflamed mucosa accompanied by bleeding on probing [BOP] and/or suppuration but without bone loss), and peri-implantitis (the presence of inflamed mucosa with positive BOP, probing depth >5 mm, and marginal bone loss >2 mm after initial remodeling).[21] Peri-implant marginal bone levels (MBLs) were evaluated on digital periapical radiographs[¶] taken using a long-cone paralleling technique at implant placement (baseline), at implant loading, and at the 5-year follow-up examination. When patients were unable to tolerate the intraoral film placement in their mouth, digital panoramic radiographs[#] were obtained. An independent calibrated examiner (GC) used image-analysis software[**] to measure the distance between the fixture head and the most coronal level of the bone deemed to be in contact with the implant surface by using an on-screen cursor at original magnification ×4. In cases where the implant head was below the margin of the crestal bone, that is, subcrestal, the value was considered as zero. The cursor was calibrated for each individual radiograph using the known diameter of the implant head. Relative mesial and distal bone height measurements were made to the nearest 0.01 mm and were averaged at a patient level. Bone loss was calculated by subtracting the marginal bone level at the 5-year follow-up examination from the baseline measurement at implant placement. Twenty randomly selected radiographs were examined twice, 1 week apart, to analyze intraexaminer reproducibility. The two-way intraclass correlation coefficient was 0.97, considered excellent.

Prosthetic complications. Prosthetic complications were divided into: 1) minor: FPD detachment, screw loosening, and fracture of occlusal ceramic material; and 2) major: fracture of the screw, abutment or framework.

Statistical Analyses

All data analyses were performed using a statistical software package.[††] Descriptive statistics were expressed as frequency and percentage or means and standard deviations, as appropriate. The patient was the statistical unit of the analyses. Differences in proportion of patients with implant failures and complications were compared between the groups using the Fisher exact test. After checking marginal bone loss data distribution for normality with the Kolmogorov–Smirnov test, the Mann–Whitney *U* test was selected to disclose differences of means between groups and to assess the effect of location, smoking, alcohol consumption, and initial periodontal condition on the 5-year marginal bone loss in each group. The Wilcoxon signed-rank test was used to detect intragroup differences in MBL values over time. A significance level of 0.05 was used for all comparisons.

RESULTS

Of the initial sample of 127 patients (282 implants), 20 patients (43 implants) were not included in the study and considered as dropouts (15.8% of patients) for the following reasons: one patient died, two patients had moved away, six patients declined to attend the 5-year follow-up visit, clinical and/or radiographic data were missing for review for eight patients, and eight patients did not regularly attend periodic follow-up visits. Data of the 107 patients that could be evaluated at the 5-year follow-up visit have been analyzed and are presented in this retrospective cohort study. The main baseline patient and implant characteristics divided by study groups are shown in Table 1. The NDI group consisted of 49 patients who received 113 implants with a diameter of 3.0 mm. The SDI group consisted of 58 patients who received 126 implants: 77 with a diameter of 4.0 mm, and 49 with a diameter of 4.5 mm. NDI and SDI groups were significantly different when compared for age ($P = 0.02$), and restoration design ($P < 0.001$), but not for sex, smoking status, alcohol consumption, parafunctional habits, history of periodontitis, and number of patients with cantilever extension or subjected to sinus lift.

Implant and Prosthesis Failure

The main results after a 5-year follow-up period are summarized in Table 2. Two implants failed in a patient of the NDI group versus four implants in four patients of the SDI group. Four failures occurred before loading: two NDIs were removed due to infection 1 month after placement, and two SDIs were

¶ Digora Optime, Soredex/Orion, Helsinki, Finland.
# Cranex Tome, Soredex/Orion.
** Digora for Windows, v.2.1, Soredex/Orion.
†† GraphPad InStat, GraphPad Software, San Diego, CA.

Table 1.

Main Patient and Implant Characteristics in the Narrow- and Standard-Diameter Groups

Variable	NDI Group	SDI Group	*P* Value
Total number of patients	49	58	
Total number of dropouts	5 (10.2)	15 (25.8)	
Mean age ± SD (years)	61.02 ± 9.76	56.77 ± 9.86	0.02*
Sex ratio (females/males)	38/11	36/22	0.09†
Location			0.24†
Maxilla	25 (51)	22 (38)	
Mandible	24 (49)	36 (62)	
Type of partial edentulism			0.59‡
Kennedy class 1	8 (16.3)	11 (18.9)	
Kennedy class 2	26 (53)	33 (56.9)	
Kennedy class 3	15 (30.7)	14 (24.2)	
Number of smokers (<20 cigarettes per day)	14 (28.5)	14 (24.1)	0.66†
Number of patients consuming alcohol (≤10 g/day)	10 (20.4)	15 (25.8)	0.81†
Number of patients with periodontitis	10 (20.4)	13 (22.4)	0.81†
Number of patients with bruxing habits	7 (14.3)	3 (5.2)	0.18†
Number of implants per patient			0.11†
Two implants	34 (70)	48 (82.7)	
Three implants	15 (30)	10 (17.3)	
Number of FPDs with cantilever extension	4 (8.2)	2 (3.4)	0.4†
FPD occlusal material			0.43‡
Zirconia-ceramic	30 (61.2)	42 (72.4)	
Metal-ceramic	6 (12.2)	8 (13.7)	
Full-zirconia	10 (20.4)	6 (10.3)	
Titanium-composite	3 (6.1)	2 (3.4)	
Restoration type			<0.001†
Number of cement-retained FPDs	36 (73.5)	23 (39.6)	
Number of screw-retained FPDs	13 (26.5)	35 (60.4)	
Abutment design for cemented FPDs			0.35†
Prefabricated	7 (19.4)	8 (34.7)	
Customized	27 (79.6)	15 (65.3)	
Number of patients subjected to sinus lift	7 (14.2)	6 (10.3)	0.56†
Total number of placed implants	113	126	
Implant length			0.06‡
11-mm-long implants	57 (50.5)	77 (61.1)	
13-mm-long implants	42 (37.2)	43 (34.1)	
15-mm-long implants	14 (12.3)	6 (4.8)	
Implant position			0.09†
Premolar sites	63 (55.7)	56 (44.5)	
Molar sites	50 (44.3)	70 (55.5)	

Data are presented as n (%) unless otherwise noted.
* Mann–Whitney *U* test.
† Fisher exact test.
‡ χ^2 test.

Table 2.

Summary of the Main Clinical Results at Patient Level After 5 Years of Follow-up

	NDI Group (n = 49)	SDI Group (n = 58)	*P* Value*
Failure of the prostheses	1	2	<0.99 (NS)
Failure of the implants	1 (two implants)	4 (four implants)	0.37 (NS)
Biologic complications	9 (six mucositis, three peri-implantitis)	12 (eight mucositis, four peri-implantitis)	0.81 (NS)
Prosthetic complications	12	2	0.001
Minor	8 (four decementations, three screw loosenings, and one ceramic veneer fracture)	2 (one screw loosening, one ceramic veneer fracture)	0.04
Major	4 (one framework fracture and three screw fractures)	0	0.04

* Fisher exact test. NS = Not significant.

lost because of lack of osseointegration at the healing abutment connection. The two other SDIs were removed after 4.5 years for an untreatable peri-implantitis. All failed implants were successfully replaced after 3 to 4 months of additional healing by an implant that was placed in an adjacent position and loaded. The difference in the proportion of implant failures was not statistically significant ($P = 0.37$, Table 2).

A total of three FPDs failed: one in the NDI group had to be remade after 4 years for a framework fracture, and two in the SDI group had to be remade after 4.5 years due to late implant failures. The difference in the proportion for FPD failures was not statistically significant ($P < 0.99$; Table 2).

Biologic Complications

Biologic complications occurred in nine patients of the NDI group and 12 patients of the SDI group during the follow-up period, with a global frequency of peri-implant pathology at the patient level of 18.3% for the NDI group and 20.7% for the SDI group. The difference in proportions was not statistically significant ($P = 0.81$; Table 2). Patients affected by peri-implant mucositis were successfully managed in both groups by interceptive supportive therapy,[22] consisting of professional cleaning with titanium curets and polishing using rubber cups and polishing paste, followed by 0.2% chlorhexidine mouthrinses, three times daily for 2 weeks. Patients with peri-implantitis were treated with resective surgery and systemic antibiotics (1 g amoxicillin or 600 mg clindamicin, twice daily for 1 week). After 5 years, clinically healthy peri-implant soft tissues were re-established in around 13 out of 15 treated implants at a reduced bone level height. In two SDIs peri-implant disease progressed, and implants were removed after 4.5 years.

MBL Radiographic Evaluation

A total of 37 panoramic and 284 periapical radiographs were analyzed at the different time points. Peri-implant MBLs could be measured at the mesial and distal aspects of all implants. Both groups gradually lost a small amount of marginal peri-implant bone during the follow-up period, and this loss was statistically significant ($P < 0.001$; Table 3). At the start of prosthetic loading, NDIs lost 0.19 ± 0.29 mm and SDIs lost 0.24 ± 0.27 mm of peri-implant bone; the between-group difference was not statistically significant ($P = 0.27$; Table 3). At 5 years, NDIs lost 0.95 ± 0.84 mm, and SDIs lost 1.2 ± 0.86 mm of peri-implant bone, and again, the between-group difference was not statistically significant ($P = 0.06$; Table 3). The frequency of patients experiencing bone loss >1 mm over the follow-up period was 36.7% (18/49) for the NDI group and 43.1% (25/58) for the SDI group. A bone loss >2 mm was found in 8.2% (4/49) of patients for the NDI group and 13.7% (8/58) for the SDI group.

Additionally, a smoking habit demonstrated a significant effect on marginal bone loss in both groups (NDI group: $P = 0.009$; SDI group: $P = 0.01$), with patients who smoked having about twice as much marginal bone loss compared with non-smoker patients (Table 4). Figures 1 and 2 show radiographic images of ten cases included in the two study groups at 5 years.

Major and Minor Prosthetic Complications

The NDI group registered 12 cases of prosthetic complications: four major ones (one framework fracture and three screw fractures) and eight minor ones (four decementations, three screw loosenings, and one ceramic veneer fracture) over the 5-year follow-up period. The SDI group registered only two minor prosthetic complications (one screw loosening and one ceramic

Table 3.

Comparison of Mean MBLs and Changes (± SDs) at Different Times Within and Between Groups

	Implant Placement (baseline)	Loading*	5 Years*	Baseline: Loading	Baseline: 5 Years
NDI group (n = 49)	0.02 ± 0.08	0.22 ± 0.33	0.98 ± 0.84	0.19 ± 0.29	0.95 ± 0.84
SDI group (n = 58)	0.03 ± 0.08	0.27 ± 0.28	1.23 ± 0.87	0.24 ± 0.27	1.2 ± 0.86
P value†				0.27	0.06

* All changes from baseline are statistically different (Wilcoxon signed-rank test, $P<0.001$).
† Mann–Whitney *U* test.

Table 4.

Evaluation of the Effect of Location, Smoking, and Initial Periodontal Condition on Marginal Bone Loss (mean ± SD; in mm) in the Study Groups

Characteristics	NDI Group	SDI Group
Location		
Maxilla	0.92 ± 0.7 (n = 25)	1.08 ± 0.08 (n = 22)
Mandible	1 ± 1.01 (n = 24)	1.25 ± 0.28 (n = 36)
P value*	0.62	0.84
Smoking		
Yes	1.49 ± 1.14 (n = 12)	1.83 ± 0.7 (n = 14)
No	0.78 ± 0.64 (n = 37)	1.02 ± 0.94 (n = 44)
P value*	0.009	0.01
Initial periodontal condition		
Periodontitis	1.26 ± 1.1 (n = 10)	1.32 ± 1.03 (n = 13)
No periodontitis	0.88 ± 0.75 (n = 39)	1.16 ± 0.71 (n = 45)
P value*	0.13	0.49
Alcohol consumption		
Yes (≤10 g/day)	1.07 ± 0.43 (n = 10)	1.31 ± 0.58 (n = 15)
No	0.93 ± 0.91 (n = 39)	1.16 ± 0.94 (n = 43)
P value*	0.06	0.14

* Mann–Whitney *U* test.

veneer fracture). The frequency of prosthetic complications at patient level was 24.5% for the NDI group and 3.4% for the SDI group. The difference in total number of prosthetic complications between the two groups was found to be statistically significant ($P = 0.001$). Minor complications were treated chairside on the same day patients came to the office through recementing/retightening the FPD or polishing minor ceramic fractures with a sequence of rubber cups. Regarding major prosthetic complications, screw fractures were resolved by removing the screw fractured inside the implant by a counter clockwise rotation with a sharp dental explorer and positioning a new screw, whereas framework fracture required the FPD to be remade. For both complication types, an adjustment of the occlusion was always performed. Of the 14 patients that experienced prosthetic complications, five belonged to Kennedy class 1, five to Kennedy class 2, and four to Kennedy class 3 with no significant effect of the partial edentulism type on the number of prosthetic complications (linear regression, $P = 0.79$).

DISCUSSION

Bone availability in the edentulous ridge determines implant dimensions, and NDIs may represent a minimally invasive treatment alternative for the rehabilitation of narrow posterior ridges (≤5.5 mm),[16,23,24] which would require a bone augmentation surgery before placement of SDIs. However, caution has been suggested in the use of NDIs in posterior areas with high occlusal loading due to risk of fatigue fracture of titanium implants, as reported in some studies.[25-27]

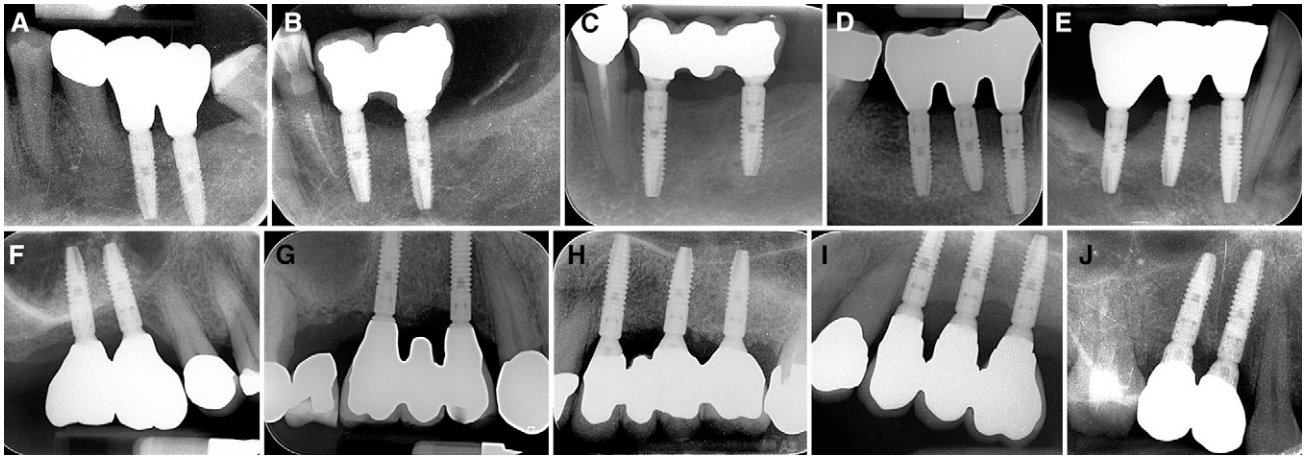

Figure 1.
*Periapical radiographs of ten cases **(A through J)** included in the NDI group at 5 years after implant placement.*

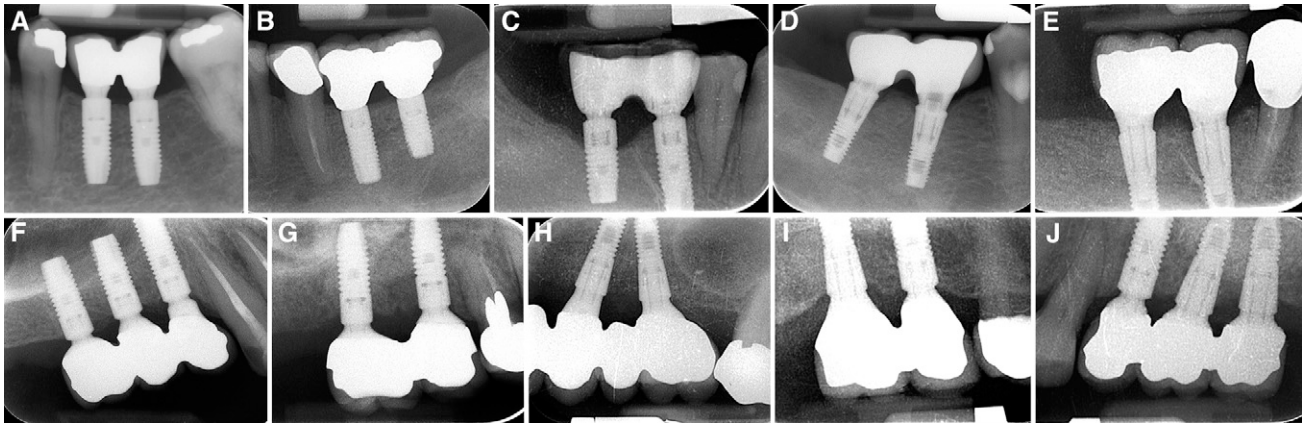

Figure 2.
*Periapical radiographs of ten cases **(A through J)** included in the SDI group at 5 years after implant placement.*

The present retrospective investigation revealed that the clinical and radiographic 5-year performance of NDIs supporting a FPD was comparable with the same treatment using SDIs when placed in posterior jaws with different bone widths.

At 5 years, implant survival rates at the patient level were similar in the NDI and SDI groups (99.1% and 96.8%, respectively). This trend was previously observed by other clinical studies.[4,27] Andersen et al.[3] reported that survival rates of NDIs and SDIs in anterior single restorations were 93.8% and 100%, respectively, after 3 years of loading. Romeo et al.[28] reported survival rates of 92% to 97.7% for NDIs and SDIs supporting both single restorations and FPDs in anterior and posterior areas over a 7-year observation period. However, a recent meta-analysis by Ortega-Oller et al.[1] showed NDIs could be at higher risk for implant failure. In particular, it was found that NDIs with a diameter <3.3 mm had failure rates 3.92 times greater than implants with a diameter ≥3.3 mm after an average follow-up time of 4 years. The authors have related this outcome to the fact that NDIs are usually placed in complicated clinical conditions and have a higher possibility of failure. Interestingly, according to that meta-analysis, increase in the failure rate was more likely if the implants were loaded in a period <3 months after placement and/or had a smooth implant surface. In the present study, the high survival rate of NDIs could be related to the fact that implants had a rough surface and were loaded after a healing period of at least 3 months in the mandible and 4 months in the maxilla. In particular, a two-stage procedure might be recommended using NDIs in maxillary posterior areas where a low trabecular density is present.

The measurement of MBLs around NDIs showed a mean value below 1 mm after 5 years since placement, which would indicate the absence of excessive

mechanical loading on the 3-mm-diameter implants. Similar radiographic results have been reported by Arisan et al.[29] and Anitua et al.[30] Furthermore, NDIs were associated with a similar bone loss at 5 years compared with SDIs. This result seems to contradict findings of previous experimental studies using finite element analyses, in which implant diameter reduction was associated with a greater stress and strain concentration around the head of the implants.[14,31] The non-significant between-group difference in marginal bone loss suggests that splinting multiple NDIs could protect against generating excessive stress and resorption in the marginal peri-implant bone.[24,32,33] Romeo et al.[28] found similar mean MBL values for NDIs and SDIs in a partially dentate population, with a significant tendency toward increased mean bone loss passing from start of loading and the latest examination after 1 to 7 years. This progressive marginal bone loss was also observed in both groups of the present study, where restorations were monitored for 5 years; however, it does not appear to have clinical significance due to the small quantity of additional bone loss since implant loading. Another important observation was that neither location nor initial periodontal status appeared to have any impact on bone loss at 5 years, whereas smoking was associated with more bone loss in both groups. According to previous clinical studies,[34-36] there is strong evidence that cigarette smoking increases risk of peri-implant bone loss.

In the current study, frequency of prosthetic complications in the NDI group (24.5%) was more than seven-fold higher compared with the SDI group (3.4%). The between-group difference was statistically significant ($P = 0.001$). When comparing prosthetic outcomes reported in the literature with regard to the complications reported in this study, trends appear similar.[1,4] Decementation and screw loosening were the most frequent complications in the NDI group, occurring at 8.2% and 6.1%, respectively. In a recent clinical study, incidences of decementations and screw loosenings were 7.1% and 3.3% for NDIs after a mean follow-up of 5 years.[37] The high number of prosthetic complications observed in the NDI group could be the result of different factors like component weakness, inadequate screw design, inadequate tightening and settling of the screw, and reduced abutment surface.[1,2,37] Furthermore, six out of 12 patients of the NDI group affected by prosthetic complications were considered to be bruxers. Several studies reported the presence of a clear relationship between bruxism and mechanical complications in implant-supported restorations.[38,39] This implies that these patients may have benefited from a preventive protocol including short-term periodic follow-up visits for occlusion adjustment and use of a nightguard prescribed from the initial stage after FPD placement. Nevertheless, 11 out of 12 of the prosthetic complications reported in the NDI group did not affect the 5-year survival of the FPDs, demonstrating that splinting NDIs can protect implants from excessive loading in posterior areas, where the more demanding occlusal forces may cause irremediable fractures of prosthetic components.[7,40] Findings from the current study appear to corroborate this concern as only one framework fracture occurred after 4 years, which determined the failure of the FPD.

In a recent meta-analysis,[21] prevalence of mucositis and peri-implantitis at the patient level were respectively 63.4% and 18.8% during 5 to 10 years of follow-up. In the present study cumulative prevalences of 13% and 6.5% for peri-implant mucositis and peri-implantitis were found in the study population. These prevalences were much lower than those reported in the previous meta-analysis, probably because the present study included compliant patients maintained under periodic hygienic control, and the follow-up time was limited to 5 years. A strict hygienic maintenance protocol was established to prevent plaque formation and reduce risk for peri-implant pathologies due to increased food impaction of FPDs supported by NDIs in the molar area. Because peri-implantitis has a late onset, tissue destruction may not be detected until observation periods of at least 10 years.[41] Considering that seven cases of peri-implantitis occurred in both groups after 5 years, it would be interesting to evaluate the possible future increase in the number of peri-implantitis cases at a longer follow-up visit. Biologic complications seemed to cluster in a determined number of patients, as five of the nine patients in the NDI group (55.5%) and five of the 12 patients in the SDI group (41.6%) also had smoking habits. This situation has been previously described in the literature, as a clinical study showed that smokers had a two-fold higher chance for the development of peri-implant pathologies than non-smokers.[42] This trend is in agreement with the findings of Saaby et al.,[43] who reported smoking as the most important risk factor for increased severity of peri-implantitis.

Results of the present study have to be interpreted with caution because of its limitations: the retrospective design and lack of comparability of treatment groups at baseline. Patients of the SDI group were greater in number, on average 5 years younger, and received about half the number of cemented FPDs compared with patients in the NDI group. The prosthetic design was chosen according to the clinical conditions of the patient and not to a specific inclusion criteria as would be the case in a prospective study. Unfortunately, little is known about the possible influence of type of restoration on implant failures and complications.[44] The doubled number of dropouts in the SDI group (25.8%) compared

with the NDI group (10.2%) is another limitation of this study, which may affect the 5-year failure rate, as these patients could be expected to have a higher failure rate compared with patients complying with the follow-up included in this study. In the current study all of the included patients had splinted implants joined under the same FPD. This should be taken into consideration when extrapolating results from the current study to other clinical situations.

CONCLUSION

Within the limitations of the present study, the 5-year results indicate that survival rate and marginal bone loss of NDIs were comparable with those of SDIs supporting FPDs in posterior jaws; however, the incidence of prosthetic complications registered for the NDI group was significantly higher than for the SDI group.

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