

# Effect of Osteoporotic Status on the Survival of Titanium Dental Implants

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**Objectives:** The aim of this study was to determine whether a diagnosis of osteoporosis affected the survival rate of osseointegrated dental implants. Other variables that were studied were age, arch location of the implant, and smoking status on the effect of dental implant survival. **Materials and Methods:** A retrospective chart review was completed on all women who were 50 years of age or older at the time of dental implant placement at the Mayo Clinic between October 1, 1983, and December 31, 2004. Osteoporotic status was defined on the basis of bone mineral density (BMD) score utilizing World Health Organization criteria. Univariate analyses were performed to evaluate the following independent variables' effect on implant survival: BMD T-score, age, osteoporosis status, arch location of the implant, and smoking status at the time of implant placement. **Results:** A total of 3,224 implants in 746 female patients 50 years of age or older at the time of implant placement were evaluated. BMD scores within 3 years of implant placement were available for 646 implants (192 patients). In this group, 37 implant failures were noted. The 5-year implant survival rate was 93.8% in the group of patients with BMD scores. In this group of 192 patients, there were 94 (49%) who were not diagnosed with osteopenia or osteoporosis, 57 (29.7%) with a diagnosis of osteopenia, and 41 (21.4%) with a diagnosis of osteoporosis. Patients with a diagnosis of osteoporosis or osteopenia were not significantly more likely to develop implant failure compared to those without such a diagnosis (HR = 1.14, 95% CI = 0.50 to 0.60, P = .76 and HR = 0.98, 95% CI = 0.40 to 2.42, P = .97, respectively). Arch location and BMD score did not have a statistically significant effect on implant survival rates. The only tested variable to demonstrate a significant effect was smoking. Implants in patients who were smokers during the time of implant placement were 2.6 times more likely to fail compared to implants placed in patients who did not smoke (HR = 2.6, 95% CI = 1.20 to 5.63; P = .016). **Conclusions:** Based upon the data derived from this retrospective study of 192 women at least 50 years of age at the time of implant placement, the following observations were made: (1) a diagnosis of osteoporosis and osteopenia did not contribute to increased risk of implant failure and (2) implants placed in patients who were smokers at the time of implant placement were 2.6 times more likely to fail than implants placed in nonsmokers. Based on these data, a diagnosis of osteoporosis or osteopenia is not a contraindication to dental implant therapy. INT J ORAL MAXILLOFAC IMPLANTS 2008;23:905-910

**Key words:** dental implants, implant survival, osteoporosis

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Compromise of systemic bone metabolism may be a risk factor affecting osseointegration and maintenance of osseointegration. One such compromising condition is osteoporosis, and despite the considerable number of women and increasing number of men with this condition, relatively little is known regarding the interplay between osteoporotic condition and dental implant survival.

Osteoporosis is a skeletal disorder characterized by compromised bone strength that predisposes a person to increased risk of fractures. The World Health Organization (WHO) defines osteoporosis based on a surrogate marker, bone mineral density (BMD). Using densitometry measurement, a patient's

BMD score can be compared to normative values for a population of healthy 20- to 40-year-olds. A "normal" BMD T-score is higher than one standard deviation below the mean (BMD score  $> -1$ ) as the term is used by the WHO. However, to limit confusion, in the remainder of this article, the term "non-OP" will be used in lieu of "normal." For a diagnosis of osteoporosis, a patient must have a BMD score more than 2.5 standard deviations (SDs) below the mean (BMD score  $< -2.5$ ). If the BMD score is between  $-2.5$  and  $-1$ , then a diagnosis of osteopenia is made.<sup>1-3</sup>

The major medical consequence of osteoporosis is osteoporotic bone fractures. Osteoporotic fractures are one of the most common causes of disability and a major contributor to medical care costs in many regions of the world. Given the changes in bone micro-architecture that accompany loss of BMD, osteoporosis may be a risk factor for dental implant survival. Unfortunately, only a few studies<sup>4-7</sup> have addressed this area of investigation, and the only one that utilized BMD score to assess osteoporotic status was limited in sample size to 14 subjects.<sup>4</sup> A recent comprehensive review of the literature concluded that: "Conflicting results highlight the controversy of whether a causal relationship between systemic bone loss and various oral conditions is present or not. Further studies, especially in gender, race, and age-specific groups, are needed to assess the role of osteoporosis in various oral conditions."<sup>8</sup>

The primary objective of this research study was to perform a retrospective chart review to determine the effect of osteoporotic status on survival of dental implants in postmenopausal women. Secondary objectives included assessing the effects of smoking status, age, and arch location on implant survival as a function of osteoporotic status.

## MATERIALS AND METHODS

A retrospective chart review was completed on all women 50 years of age or older who had had a dental implant placed at the Mayo Clinic between October 1, 1983, and December 31, 2004. The dental implants were placed by either the Division of Oral and Maxillofacial Surgery or the Division of Periodontics. The list of patients was generated by performing a "query" within the Dental Implant Tracker (Implant Tracking Systems LLC, West Hartford, CT) program by using the guidelines listed previously. The Dental Implant Tracker is a program generated within Microsoft Access (Microsoft Corporation, Redmond, WA) and updated when a patient has a dental implant placed, restored, or repaired within the Mayo Clinic system. This retrospective chart review of

patients who had not denied research authorization was approved by the Mayo Clinic Institutional Review Board.

The medical and dental charts of each patient were reviewed to collect the following information: (1) BMD T-score within 3 years of implant placement if available, (2) osteoporotic diagnosis based on BMD T-score, (3) arch location of the implant(s), (4) smoking status at time of implant placement, and (5) any implant failures. Since there is no evidence to indicate that osteoporotic status influences frequency, duration, or intensity of infection, an implant failure was defined as any implant that had to be removed due to any reason other than infection or internal implant manufacturing defect. If purulence was noted at the time of implant removal, the failure was considered infection-related. The retrospective chart review resulted in 192 patients (646 implants) who had records of a dual x-ray absorptiometry (DEXA) scan taken and a BMD score available within 3 years of implant placement.

Implant survival was estimated using the Kaplan-Meier method. Duration of follow-up was calculated from the date of implant placement to the date of failure or last follow-up. Since osteoporotic status has not been associated with risk of oral infection, implants that failed due to infection were censored at the time of infection and not counted as failures. The associations between implant survival and patient/implant characteristics were estimated by fitting univariate marginal Cox proportional hazard models. The robust standard error method of Lin and Wei was used to account for the correlation between multiple implants within a patient.<sup>9</sup> Associations were summarized by calculating hazard ratios (HR) and corresponding 95% confidence intervals (95% CI) using the robust standard errors. Statistical analyses were performed using the SAS software package, version 9.1 (SAS Institute, Cary, NC).

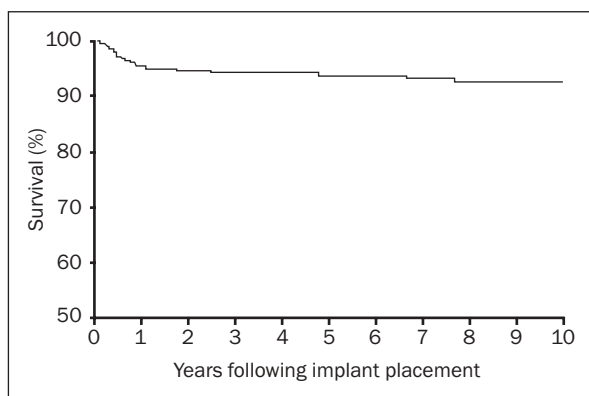
## RESULTS

Of a total of 3,224 implants placed in 746 female patients over the age of 50 years at the time of implant placement, 646 implants were placed in 192 postmenopausal females with a BMD T-score within 3 years of implant placement. Chart review revealed 39 implant failures that had to be removed from the oral cavity. Of these failed implants, 2 were associated with purulence (infection) and were censored from the analysis of time to implant failure. Of the remaining 37 failures considered for this study, 35 failed either due to failure to achieve osseointegration (removal before prosthesis insertion) or due to

**Table 1** Demographics of Subject Population, Overall and by BMD T-score Diagnosis

	Total (n = 192)	Non-OP (n = 94)	Osteopenia (n = 57)	Osteoporosis (n = 41)
Age (years)*				
Mean (SD)	63.4 (8.5)	61.8 (8.3)	64.0 (8.9)	66.0 (7.7)
Range	50.3–84.9	50.4–82.9	50.3–84.9	52.0–84.9
Smokers (%)*	24 (12.5)	14 (14.9)	6 (10.5)	4 (7.8)
Number of implants per patient				
Mean (SD)	3.4 (2.7)	3.3 (3.5)	3.4 (3.1)	3.5 (2.6)
Median	2	2	2	2
Range	1–15	1–11	1–15	1–10
Implant number (%) by location				
Anterior mandible	129 (20)	48 (15.7)	48 (24.4)	33 (23.1)
Posterior mandible	249 (38.5)	120 (39.2)	81 (41.1)	48 (33.6)
Anterior maxilla	94 (14.6)	48 (15.7)	23 (11.7)	23 (16.1)
Posterior maxilla	174 (26.9)	90 (29.4)	45 (22.8)	39 (27.3)
Total no. of implants	646	306	197	143

\* For the purposes of this table, these variables are defined at the time of the first implant placement in the study period. However, each of these variables was collected at the time of each implant placement for use in the analysis of factors associated with implant failure.

**Fig 1** Kaplan-Meier implant survival rates.

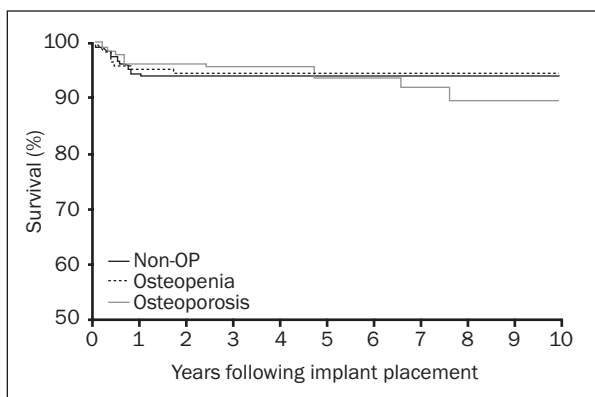
loss of osseointegration (in a total of 25 patients) and 2 failed due to implant fracture (in 2 separate patients). The Kaplan-Meier 5- and 10-year survival rates for the 646 implants placed in the 192 subjects were 93.8% and 92.5%, respectively (Fig 1). Among the implants that had not failed, the mean follow-up was 5.4 years, with a range of 11 days to 20.4 years. The mean age of the women studied was 63.4 years, with a range of 50.3 to 84.9 years. Patient demographics are summarized in Table 1.

The osteoporotic diagnosis of each patient based on BMD T-score was distributed as follows: 49% of patients were diagnosed as “non-OP”; 29.7% had a diagnosis of osteopenia, and 21.4% had a diagnosis of osteoporosis. There were 10 implant failures in the osteopenia group and 10 in the osteoporosis group. The other 17 failures occurred in the group of patients with a non-OP diagnosis. Patients with a diagnosis of osteoporosis or osteopenia were not significantly more likely to develop implant failure compared to those with a non-OP BMD T-score (HR =

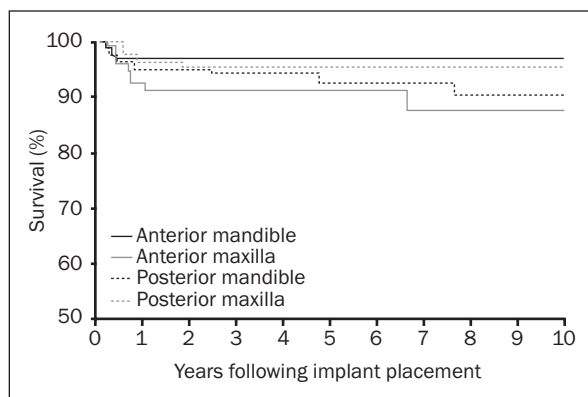
1.14, 95% CI = 0.50 to 2.60,  $P = .76$  and HR = 0.98; 95% CI = 0.40 to 2.42,  $P = .97$ , respectively; Fig 2). The mean BMD T-score was  $-1.0$ , with a range of  $-4.79$  to  $5.9$ . There was no statistically significant association between BMD T-score and implant survival (HR per 1 unit decrease = 1.12, 95% CI = 0.93 to 1.35,  $P = .25$ ).

No significant association between arch location (anterior maxilla, posterior maxilla, anterior mandible, posterior mandible) and implant failure was identified (Fig 3). The majority of implants in the current study were placed in the posterior mandible, with the least number in the anterior maxilla (Table 1). The majority of the implant failures occurred in the posterior mandible, where 16 failures were noted. There were 4 failures in the anterior mandible, 9 in the anterior maxilla, and 8 in the posterior maxilla.

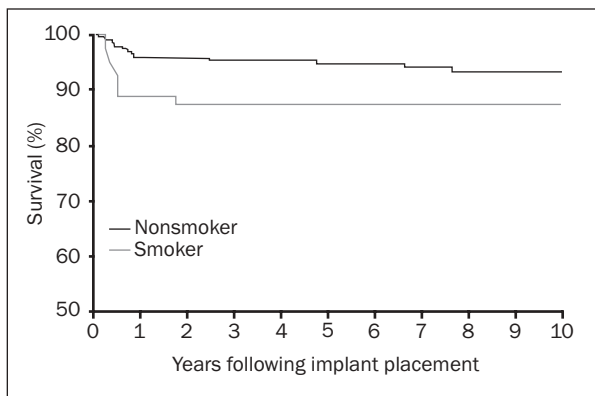
Overall, 24 (12.5%) of the 192 patients were smoking at the time of implant placement. However, it was not possible to quantify the level of smoking for these patients. Active smoking during the time of implant placement had a statistically significant



**Fig 2** Effect of osteoporotic status on implant survival.



**Fig 3** Effect of arch location on implant survival.



**Fig 4** Effect of smoking status on implant survival.

effect ( $P = .016$ ) on implant failure. In these smokers, the implants were 2.6 times more likely to fail compared to implants in patients who did not smoke ( $HR = 2.6$ ,  $95\% \text{ CI} = 1.20 \text{ to } 5.63$ ,  $P = .016$ ). There were 83 implants placed in smokers with 10 failures and 547 implants placed in nonsmokers with 27 failures. There was an 87.3% implant survival rate for smokers at 5 and 10 years. For the nonsmokers, there was a 94.6% and 93.1% implant survival rate at 5 and 10 years, respectively (Fig 4). When comparing smokers in each of the 3 BMD diagnosis groups, there were 7 implant failures found in smokers with either a diagnosis of osteoporosis or osteopenia compared to only 3 failures in smokers with a non-OP diagnosis. However, this was not a statistically significant difference. In general, any group that smoked, regardless of BMD diagnosis, had poorer long-term implant survival rates.

## DISCUSSION

Success and survival rates for osseointegrated dental implants are well documented. However, the survival and predictability of dental implants in patients with bone metabolism disorders such as osteoporosis is unknown. In addition, many patients are living longer and presenting with a multitude of systemic concerns that can affect the health and longevity of dental rehabilitation. This study was conducted to establish guidelines for discussing dental implant therapy with patients who are osteoporotic.

The most common sites to perform a DEXA scan are the spine, total hip, femur neck, and radius. BMD scores from the spine predominated (90.6% of measurements) in the present study population. If the spine was not tested, either the femur neck (8% of measurements) or the radius (1% of measurements) was used. There is a significant difference in the prevalence of osteoporosis diagnosed by bone densitometry when utilizing the spine versus neck of the femur and/or total hip.<sup>10</sup> Densitometry obtained at the lumbar spine results in a higher proportion of subjects diagnosed as having osteoporosis in every age group except for those aged 30 to 49 years. A more conservative approach is recommended by experts who believe that the diagnosis of osteoporosis be restricted to densitometry at the hip because this site best predicts fractures of the hip.<sup>11</sup> However, in the present study group of postmenopausal women 50 years of age or older, the spine was most frequently used to test BMD due to the fact that the spine is the site most likely to show low BMD T-scores resulting in a diagnosis of osteopenia or

osteoporosis. This approach enhanced the sensitivity of the study to detect those patients with a diagnosis of osteoporosis. This resulted in a large number of subjects to evaluate for an interaction between osteoporotic diagnosis and implant survival. Excellent long-term implant survival rates in the general population have been well documented.<sup>12-17</sup> The data from the present study supports these findings, since an overall 10-year survival rate by 10 years of 92.5% in the present study population was observed.

An active smoking habit is a concern when considering dental implant placement. Previous studies have shown that smoking is the most identifiable risk factor for implant failure<sup>18-21</sup> and Klokkevold and Han<sup>22</sup> found an implant failure rate of 20% in patients who reported a past history of smoking. However, a recent systematic review did not share same conclusion.<sup>23</sup> The present study documented only those patients who were current smokers at the time of implant placement. In regard to smoking, implants in smokers were 2.6 times more likely to fail than implants in patients who did not smoke. The failure rate by 10 years in smokers in the present study group was 12.7%. When looking at the survival rate charts for smokers (Fig 4), there is a trend for more implant failures in patients who smoke. Also of note, most implants in smokers failed within the first year, while the survival rates appeared to level out from year 2 onward. These findings are consistent throughout the subject population, independent of BMD T-score and osteoporotic diagnosis.

There are differences in bone quality in both the mandible and the maxilla. There also are differences in bone quality between the anterior and posterior regions of each jaw. In this study, in agreement with previous findings,<sup>17,24</sup> arch location of the implant was not found to be significantly associated with implant failure (Fig 3). Whether the implant surface affects implant survival in osteoporotic patients has not been reported. Four different surfaces of implants were involved in this study: machined titanium; anodized titanium; sandblasted, large-grit, acid-etched titanium; and plasma-sprayed titanium. Future analyses will report in greater detail that an effect of implant surface as it relates to osteoporotic status was not observed.

The main focus of this paper was to determine if practitioners can recommend, with a reasonable degree of confidence, dental implant therapy for patients who have been diagnosed with osteoporosis or osteopenia. The present study shows that there is no statistically significant effect of a diagnosis of osteoporosis or osteopenia on the failure rates of dental implants. It is also shown that no correlation between BMD T-score and dental implant failure exists.

## CONCLUSIONS

Based upon this retrospective chart review of 192 patients, 94 of whom were diagnosed as being “non-osteopenic/non-osteoporotic” with regard to BMD, 57 of whom were diagnosed as osteopenic with regard to BMD, and 41 of whom were diagnosed as osteoporotic with regard to BMD, the following conclusions were made:

1. Dental implant survival rates in this group of patients were encouraging, with a 10-year survival rate of 92.5%.
2. Implants placed in smokers were 2.6 times more likely to fail than implants placed in nonsmokers. The difference between smokers and nonsmokers was most evident in the first year after implant placement.
3. A diagnosis of osteoporosis or osteopenia is not a contraindication to dental implant therapy.

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