

## The Effect of Cigarette Smoking and Native Bone Height on Dental Implants Placed Immediately in Sinuses Grafted by Hydraulic Condensation



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*The purpose of this study was to determine the effect of cigarette smoking and residual native bone height on the survival of dental implants placed immediately in grafted sinuses. In this retrospective study, 334 subject records were screened, and 75 subjects (155 implants) were included. Data collection based on treatment notes and radiographs included age, sex, smoking status, sinus floor bone height, dental implant information, and implant survival. The survival rates of implants for nonsmokers and smokers at stage-two surgery were 93% and 84%, respectively. After 12 months of functional loading, the survival rates of implants for nonsmokers and smokers were 87% (81 of 93) and 79% (49 of 62), respectively ( $P < .000$ ). Analysis revealed that the effect of smoking on implant survival is significant when the preoperative bone height is less than 4 mm, with an 82.4% implant survival rate in nonsmokers compared to 60% in smokers ( $P < .05$ ). Smoking should be considered as a high risk factor when implants are placed immediately in grafted sinuses, particularly in areas of limited bone height. (Int J Periodontics Restorative Dent 2012;32:255–261.)*

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Currently, there are approximately 50 million smokers in the United States.<sup>1</sup> Smokers have an increased prevalence of periodontal disease, tooth loss, and oral cancer. In addition, wound healing of oral tissues has been shown to be impaired, and this effect may be dose-dependent. Current and lifetime tobacco smoking has been associated with deterioration in bone quality.<sup>2</sup> Therefore, it has been postulated that this could influence dental implant survival. De Bruyn and Collaert<sup>3</sup> noted that failures in smokers were generally associated with poor bone quality and suggested that improving bone quantity and quality may reduce early failure rates (before loading). There have been several reports associating implant failure with smoking.<sup>4,5</sup> It has also been suggested that exposure of the peri-implant tissue to smoke and not the failure of the biologic process of osseointegration results in lower survival rates.<sup>6</sup> Smoking has also been shown to be detrimental to implant survival in augmented ridges. Mayfield et al<sup>7</sup> reported success rates of 100% for implants

placed in nonsmokers and 43% for implants placed in smokers. Jensen et al<sup>8</sup> demonstrated that smoking reduced the survival of dental implants placed in grafted maxillary sinuses. The purpose of this study was to determine the effect of cigarette smoking and residual native bone height on survival of implants placed immediately in grafted sinuses.

## Method and materials

### *Data collection*

In this retrospective study, records from subjects who had been treated with the hydraulic sinus condensing technique performed by two surgeons from two different dental offices were screened. The implants were all placed immediately in grafted sinuses and submerged for the healing period. The technique used in this study was a modification of the traditional transalveolar sinus elevation technique, termed the *minimally invasive hydraulic sinus condensing technique*.<sup>9</sup> The implants were then exposed and restored within 1 month. A database was generated that included age, sex, smoking status, native residual sinus floor bone height, dental implant information, and implant survival. Exclusion criteria were patients with occurrence of uncontrolled systemic disease, pathology, insufficient follow-up (subjects required to have implants loaded for at least 12 months), or unreadable radiographs.

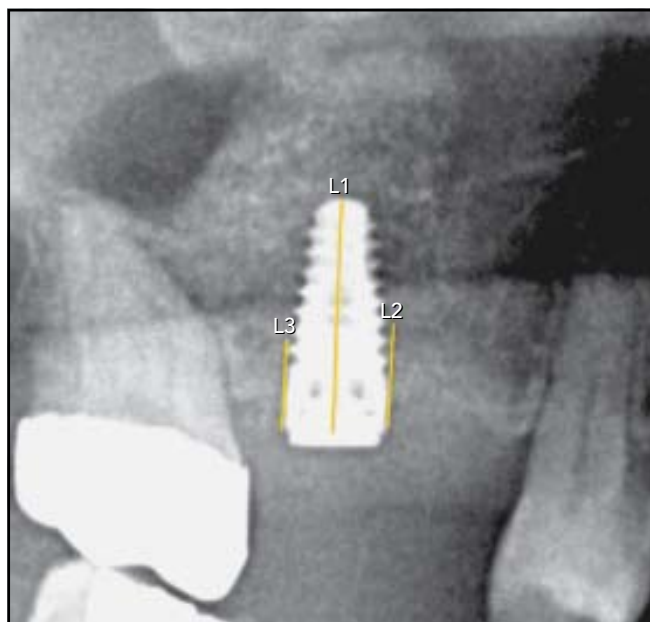
### *Radiographic analysis*

Digital radiographs were used when available. Film-based radiographs were digitized by scanning. Immediate postsurgical and further postoperative radiographs were required for measurement. Radiographs were examined using a custom macro with 22.4× magnification with Inspector 2.2 software (Matrox). The examiner was also calibrated with a resultant standard deviation of  $\pm 0.05$  mm. Pretreatment bone height below the sinus floor was measured in pixels and converted into millimeters using known implant lengths (Figs 1a and 1b). Measurements for the surgical bone height were taken from both the mesial and distal aspects of the implants, averaged, and categorized into three groups (0 to 4.0 mm, 4.1 to 8.0 mm, and 8.1 to 12.0 mm).

Criteria for implant survival in this retrospective study were largely based on the radiographs and clinical examination as follows: functioning in the oral cavity, no evidence of peri-implant radiolucency, no mobility, and no persistent pain, discomfort, or infection attributable to the implants. The last two criteria were abstracted from the treatment notes.

### *Statistical analysis*

Demographic data were analyzed using basic statistics (eg, mean, standard deviation). Odds ratios were used to compare implant survival rates between smokers



	X1	Y1	X2	Y2	Info	Info
Line 1	808	744	813	615	129 pixels	88 degree
Line 2	844	741	847	685	56 pixels	87 degree
Line 3	774	743	777	693	50 pixels	87 degree

**Figs 1a and 1b** Radiographic measurements of pretreatment bone height below the sinus floor in pixels and angulations.

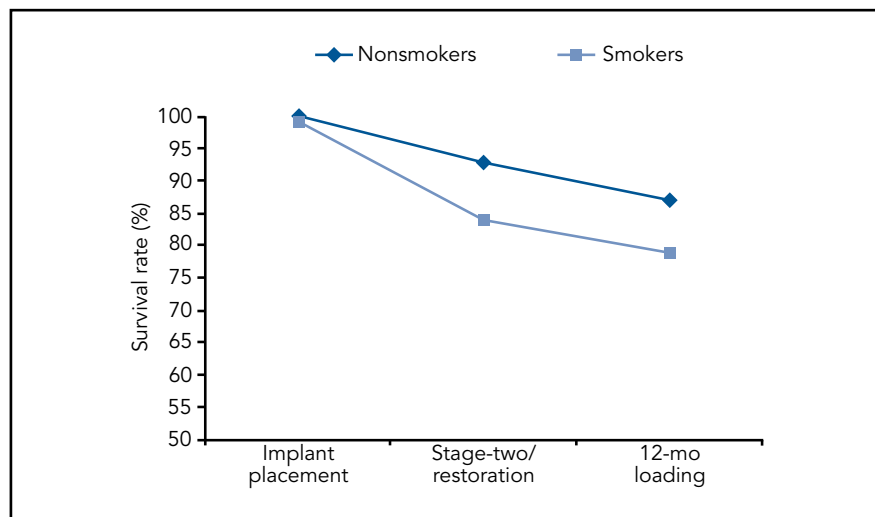
and nonsmokers. The Pearson chi-square test and Kaplan-Meier analysis were used to analyze cumulative implant survival rates between smokers and nonsmokers over the study period. The Pearson chi-square test was also used to compare the effect of smoking on implant survival rates with respect to surgical bone height.

## Results

### Sample distribution

A total of 334 patient records were screened, and 75 subjects with 155 implants were included in this

study. The mean age at the time of implant placement was 59.6 years. There were 32 men and 43 women. Of the 32 men, 20 were nonsmokers and 12 were smokers; of the 43 women, 27 were nonsmokers and 16 were smokers. Ninety-one sinus grafts were performed: 54 in nonsmokers and 37 in smokers. Ninety-four implants were inserted in nonsmokers and 62 implants in smokers. The mean native residual bone height below the sinus floor was  $4.85 \pm 0.16$  mm. Fifty-nine implants were placed with 0 to 4.0 mm of bone height, 86 implants were placed with 4.1 to 8.0 mm of bone height, and 10 implants were placed with 8.1 to 12.0 mm of bone height.



**Fig 2 (left)** Cumulative survival rate of implants at 12 months.

**Table 1** Cumulative survival rate of implants after 12 months

	Implant placement	Stage-two/restoration	12-mo loading
Nonsmoker	100%	92% (86/93)	87% (81/93)*
Smoker	100%	84% (52/62)	79% (49/62)†

\*Five implants failed during function and 7 before or at stage-two surgery, for a total of 12 implants.

†Three implants failed during function and 10 before or at stage-two surgery, for a total of 13 implants.

### Cumulative implant survival rates and odds ratio

Implants were uncovered and restored within 1 month. The overall survival rates at stage-two surgery and after 12 months of loading were 88.5% and 83%, respectively. The survival rates of implants for nonsmokers and smokers at stage-two surgery were 92% and 84%, respectively. After 12 months of functional

loading, the survival rates of implants for nonsmokers and smokers were 87% and 79%, respectively. Chi-square analysis revealed a significance in favor of nonsmokers ( $P < .000$ ) (Fig 2 and Table 1). The odds ratios of implant survival versus smoking and sex are presented in Tables 2 and 3. Based on these data, there was a 1.8× higher chance of implant failure in smokers compared to nonsmokers at the

12-month follow-up. Using the chi-square test, the difference was statistically significant ( $P = .001$ ).

### Native residual bone height and failure versus smoking status

Surgical bone heights below the sinus floor were categorized into three groups: 0 to 4.0 mm, 4.1 to

**Table 2** Odds ratio of implant survival versus smoking

	Survival	Failure	Odds ratio
Smoker	49	13	1.8
Nonsmoker	81	12	

**Table 3** Odds ratio of implant survival versus sex

	Survival	Failure	Total	Odds ratio
Male	56	15	71	1.1
Female	68	16	84	
Total	124	31	155	–

**Table 4** Implant failure between nonsmokers and smokers at 12 months vs preoperative bone height

	Preoperative bone height		
	0–4 mm	4.1–8.1 mm	8.1–12 mm
Implant failures in nonsmokers	6/34	6/51	0/8
Percentage of survival	82.4%	88.2%	100.0%
Implant failures in smokers	10/25	3/35	0/2
Percentage of survival	60.0%	91.4%	100.0%

8.0 mm, and 8.1 to 12.0 mm. Failure of implants between nonsmokers and smokers was calculated at the end of the first year based on the surgical bone height (Table 4). The results indicate that there were more implant failures with thinner preoperative native residual bone height. The difference was even greater and statistically significant between smokers and nonsmokers when analyzed using the chi-square

test ( $P < .05$ ). In other words, the effect of smoking on the implant survival rate was significant when the presurgical bone height was less than 4.0 mm.

### Discussion

The placement of dental implants in the posterior maxilla often involves the augmentation of bone

in the sinus. Since the first description of the lateral window approach to sinus augmentation, several modifications have occurred, most notably the crestal approach, as outlined by Summers.<sup>10</sup> In a consensus conference report, Jensen et al reviewed sinus augmentation data collected from 38 surgeons, which included 1,007 sinus grafts with 2,997 implants followed for up to 10 years.<sup>8</sup> An overall success

rate of 90% was reported for implants with at least 3 years of function. A risk factor for implant failure was found to be cigarette smoking. A 12.7% failure rate was noted in smokers compared to only 4.8% in nonsmokers. Of the implants that failed, smoking was a factor in approximately 30%.

In the systematic review by Klokkevold and Han,<sup>11</sup> the pooled survival rates between smokers and nonsmokers were 89.7% and 93.3%, respectively. The difference of 2.68% was determined to be statistically significant. In a meta-analysis by Strietzel et al,<sup>12</sup> the odds ratio of implant failure was 2.64 when smokers and nonsmokers were compared. Furthermore, when implants were placed with vertical or horizontal augmentation (sinus elevation or guided bone regeneration), smokers had an increased risk of implant failure (odds ratio, 3.61) compared to nonsmokers.

A recent review article from the Fourth ITI Consensus Conference evaluated the effect of smoking on implant survival.<sup>13</sup> A total of 88 publications were included, with only 7 investigations reporting the survival rates of implants inserted in smokers. The survival rates ranged from 26.09% to 94.1%. In this review, the odds ratio of implant failure between smokers and nonsmokers when placed with simultaneous sinus augmentation was 1.8.<sup>13</sup>

In this study, the sinus augmentation procedures were performed from a crestal approach. It has been postulated that the preoperative bone height below the sinus

may influence the survival rate of implants and the surgical approach used (crestal or lateral window). Therefore, it is interesting to evaluate if the lateral window approach is warranted when the bone height is less than 5 mm. Furthermore, there has been no consensus on an absolute native residual bone height when implants are placed simultaneously with bone grafts. In 2004, Toffler<sup>14</sup> presented results on implant survival rates with different bone heights. A residual bone height of 5 mm or more had a 94.7% success rate, but with a residual bone height of 4 mm or less, the survival rate dropped to 73.3%. The implants were placed simultaneously with bone grafts, and the investigator stated that the primary determinant of implant survival was the pretreatment height of the residual alveolus. Implant type and proportion of autogenous grafts to xenograft had a much weaker influence on implant survival.

When the patient data were stratified according to presurgical bone height, the review found that minimal bone was possibly an important factor in the failure to establish or maintain osseointegration.<sup>8</sup> Specifically, failures occurred only with implants placed when bone height was less than 8 mm. In contrast, Peleg et al<sup>15</sup> reported a 97% survival rate over 9 years with a lateral window approach in an area with 1 to 7 mm of residual bone.

In the current study, the preoperative bone heights were categorized into three groups: 4 mm or

less, 4.1 to 8.0 mm, and 8.1 to 12.0 mm. The implants were also differentiated between smokers and nonsmokers. There was a significantly greater difference between the survival rates of implants placed in smokers with 4 mm or less of bone height compared to nonsmokers (60% vs 82%) than in smokers with 4.1 to 8.0 mm of bone height compared to nonsmokers (88% vs 91%), and the effect of smoking on implant survival was significant when the preoperative bone height was less than 4 mm ( $P < .05$ ). These results clearly indicate that in smokers, implants should not be placed simultaneously when the preoperative bone height is less than 4 mm. Conversely, sinus augmentation with a crestal approach in nonsmokers with a preoperative bone height less than 4 mm may be a reasonable approach for clinicians. Nevertheless, one should keep in mind that the implants analyzed in this study have different lengths of follow-up periods, and the results may be biased.

The retrospective nature of this study does have several limitations. The major disadvantage was that all the data obtained were based on patient charts and radiographs. As a result, patients were typically excluded because of missing data. A second limitation was the classification of smoking status. Patients were categorized into two groups: smoking or nonsmoking. In future investigations, a smoking questionnaire should contain past smoking history, length of time, type of smoking, and quantity of cigarettes

per day. Even though the dosage effect and duration of smoking need to be assessed with further studies,<sup>16</sup> according to Sánchez-Pérez et al,<sup>17</sup> the relative risk of implant loss is 10.1% in light or moderate smokers (< 20 cigarettes per day) compared to heavy smokers, with a relative risk of implant loss being 30.8%. Another disadvantage of the retrospective study was that radiographs were not standardized. Furthermore, the bone heights measured on the mesial and distal aspects of the implants could also be biased since the thickness of the bone height may be thinner, especially in cases of immediate placement. Lastly, the implant survival rate may also be affected by the prosthesis (full arch vs single). Because of the limited sample, there is not enough evidence showing that there is a direct relationship between implant survival rate and the type of prosthesis, as has been published.<sup>18,19</sup>

## Conclusion

In this retrospective study, all implants were placed immediately after sinus elevation procedures were accomplished from a crestal approach. The effect of smoking on implant survival rates has been documented; however, its effect on implants placed simultaneously with sinus elevation procedures carried out from a crestal approach has not been well characterized. The results of this study indicate that smoking increases the failure

rate of implants by two times within the first year of functional loading. The deleterious effect of smoking was also shown to reduce the survival rate of implants when placed with less than 4 mm of bone height. However, the effect of smoking was not as noticeable with increased preoperative bone height. When implants are placed simultaneously with a sinus lift procedure using a crestal approach, smoking should be considered as a major risk factor, especially with preoperative bone heights less than 4 mm.

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