

# The Effect of Smoking on Achieving Osseointegration of Surface-Modified Implants: A Clinical Report

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**Purpose:** The present study evaluated the effect of smoking on achieving initial osseointegration when surface-modified dental implants were used. **Materials and Methods:** During an 18-month period in a private practice setting, 1,183 implants were placed in 461 patients. The group of smokers consisted of patients who smoked a half pack or more of cigarettes per day. **Results:** The overall success rate for smokers and non-smokers in achieving osseointegration was 98.1%. Ninety-seven percent of the implants placed in smokers osseointegrated successfully, and 98.4% of implants placed in non-smokers osseointegrated successfully ( $P < .05$ ). **Discussion:** The surface of an implant may be a critical determinant for achieving osseointegration in patients who smoke. **Conclusion:** It appears from this short-term retrospective study that smoking does not play a significant role in achieving the osseointegration of surface-modified dental implants. (INT J ORAL MAXILLOFAC IMPLANTS 2002;17:816–819)

**Key words:** bone density, dental implants, dental restoration failure, osseointegration, smoking, surface properties

The success of osseointegration has been documented by Adell and coworkers,<sup>1</sup> Buser and colleagues,<sup>2</sup> and others. Osseointegration between an endosseous titanium implant and bone can be expected greater than 85% of the time when an implant is placed. Failure to achieve osseointegration has been related to several factors. Two of these risk factors include poor bone quality and smoking. Poor bone quality may lead to inadequate primary implant stability, resulting in excessive micromotion and implant failure. With machined-surface implants, Jaffin and Berman reported a 35% failure rate in achieving initial osseointegration in Type IV bone, compared to a 3% failure rate in Types I, II, and III bone.<sup>3</sup> With regard to smoking, several

studies have shown a greater incidence of failure to achieve osseointegration in smokers compared to non-smokers. Bain and Moy achieved a 11.3% failure rate in smokers compared to a 4.8% failure rate in non-smokers.<sup>4</sup> DeBruyn and Collaert found smokers to have a 6% failure rate and non-smokers a 1% failure rate.<sup>5</sup> Their study indicated that there was no difference between smokers and non-smokers in the mandible, whereas in the maxilla, a 9% failure rate was noted for smokers compared to a 1% failure rate for non-smokers.

A common feature of the above studies is that they all used machined-surface screw-type implants. Recently, extensive research has resulted in the development of surface-modified implants. These implants have roughened surfaces created through coatings, blasting by various substances, acid treatment, or a combination of treatments.<sup>6</sup> This results in a very rough, highly irregular surface with depressions and indentations, which lead to increased osteoconductivity and greater bone-to-implant contact.<sup>7–9</sup> Although osseointegration can successfully be achieved utilizing smooth and rough

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implants, studies have shown a significantly greater early success rate using rough systems.<sup>10</sup> This difference is magnified when working in the posterior maxilla, where bone quality is poorer. In this regard, Trisi and coworkers, when comparing smooth and rough implants in low-density jawbone, showed that the rough surface dramatically enhanced the amount of bone-to-implant contact.<sup>11</sup>

Previous studies have been unable to explain why there was an increased failure rate in smokers compared to non-smokers. The medical literature contains numerous publications correlating smoking with less dense bone. Assuming smokers have poorer bone quality and machined-surface implants integrate with less predictability in Type IV bone, while surface-modified implants appear to integrate with a high degree of predictability in both high- and low-density bone, it was the purpose of this study to determine the effects of smoking in achieving initial osseointegration utilizing a surface-modified implant.

## MATERIALS AND METHODS

The study population included all patients who received ITI SLA (Straumann USA, Waltham, MA) implants in a private practice setting between January 1999 and June 2000 (18 months). A similar protocol was followed by each of 2 surgeons and included, but was not limited to, preoperative radiographs, sterile surgical technique, single-stage surgery, pre- and postoperative antibiotics, and a healing time of 6 to 12 weeks. Confirmation of initial osseointegration was made after the designated healing time by torquing the prosthetic abutment to 35 Ncm and inspecting a radiograph. The implant was considered a success if there were no clinical signs or symptoms of peri-implant pathosis, no clinically visible mobility, and no evidence of bone loss since initial placement as determined by conventional periapical (non-standardized) radiographs.

Patients were divided into 2 groups: smokers and non-smokers. Smokers consisted of patients who smoked half a pack or more of cigarettes a day at the time of surgery. Bone quality was noted for each implant at the time of surgery and ranged from Type I (the densest bone) to Type IV (poor bone quality) as described by Lekholm and Zarb.<sup>12</sup> Assessments were performed regarding individual implants, rather than patients, since implants placed in each patient were placed in sites of differing bone quality and were subject to different occlusal forces during healing. No data were accumulated regarding the loading experience of implants.

## RESULTS

A total of 1,183 SLA implants were placed in 461 patients. Two hundred sixty-nine implants were placed in 72 smokers, and 914 implants were placed in 389 non-smokers. Twenty-three implants had not integrated as determined at the time of abutment connection, for a cumulative success rate of 98.1%. Eight implants were lost in the smoking group, for a success rate of 97.0%. Fifteen implants were lost in the non-smoking group, for a success rate of 98.4%. The success rates were not statistically significantly different between smokers and non-smokers (Table 1).

Analysis of implant success by arch revealed that in the maxilla, 16 of 826 implants failed to integrate, for a success rate of 97.5%. In the mandible, 7 of 357 implants failed to integrate, for a success rate of 98.0%. The success rates were not statistically significant between arches.

Analysis of implant success based on bone type revealed the following success rates: 95.6% in Type I bone, 97.7% in Type II bone, 98.2% in Type III bone, and 99.3% in Type IV bone. No statistically significant difference was noted for implant success based on bone type (Table 2).

Bone quality in smokers was of Types I, II, and III 92.6% of the time, compared to 86.8% of the time in the non-smoking group. There was no significant difference in bone quality between smokers and non-smokers (Table 3).

## DISCUSSION

Smoking has proven to be detrimental in achieving and maintaining good oral health. The correlation between smoking and periodontal disease, root caries, delayed wound healing, and oral cancers has been documented.<sup>13-16</sup> Additionally, the literature contains reports of decreased ability to achieve osseointegration in smokers compared to non-smokers; however, the reasons for this are not clear.

In a study by Bain and Moy, 88% of the implants in smokers integrated successfully, despite the fact that implants failed twice as often in smokers as in non-smokers.<sup>4</sup> Bone quality has been considered by many to be the single most important factor in achieving successful osseointegration. In general, good bone quality allows for better primary implant stability and undisturbed healing. Although the Bain and Moy paper described the successful and failed implants with respect to implant location, it did not delineate the results by bone type. Similarly, DeBruyn and Collaert did not categorize success of

**Table 1 Analysis of Implant Success by Smoking Status**

Group	No. of patients	No. of implants	No. of failures	Success rate (%)
Smoker	72	269	8	97.03
Non-smoker	389	914	15	98.36
Total	461	1183	23	98.06

Student *t* test (level of significance:  $P < .05$ ).

**Table 2 Analysis of Implant Success by Bone Type**

Bone type	No. of implants	No. of failures	Success rate (%)
I	24	1	95.6
II	398	9	97.7
III	620	11	98.2
IV	141	1	99.3

Student *t* test (level of significance:  $P < .05$ ).

**Table 3 Analysis of Bone with Respect to Smoking Status**

Bone type	Implants in smokers (n and %)	Implants in non-smokers (n and %)	Total
I	5 (1.9%)	19 (2.1%)	24
II	108 (40.1%)	290 (31.7%)	398
III	136 (50.6%)	484 (52.9%)	620
IV	20 (7.4%)	121 (13.2%)	141

Student *t* test (level of significance:  $P < .05$ ).

implant integration by bone type.<sup>5</sup> However, they did note that in the mandible, where the bone is usually denser than in the maxilla,<sup>17</sup> there was no difference in implant success between smokers and non-smokers.

Numerous studies have documented that surface-modified implants osseointegrate with good predictability in Type IV bone. In this respect, Lazara and coworkers reported that in poor-quality bone, a significantly higher percentage of bone contacted roughened, acid-etched implants than machined-surface implants of the same design.<sup>18</sup> Wiskott and Belser<sup>19</sup> speculated that the reason for this is that a smooth-surface implant does not provide adequate biomechanical coupling with the surrounding bone and thereby results in less bone formation. However, a roughened surface creates a heterogeneous stress field around the implant, leading to increased bone formation.<sup>19</sup> The present results appear to support this finding, since there was a 99.3% success rate in Type IV bone and no clinical difference between other types of bone. In contrast to the DeBruyn and Collaert study,<sup>5</sup> the present study, when utilizing surface-modified implants, did not show a difference in success between the mandible and maxilla.

In the medical literature, numerous reports state that patients who smoke tend to have decreased bone quality. In this regard, Ortego and associates reported a significant decrease in bone mineral density in smokers compared to non-smokers.<sup>20</sup> In addition,

Slemenda concluded in a review article that the bone density of women who smoked was significantly lower than that of their twin sisters who did not smoke.<sup>21</sup> Thus, the bone in smokers may possibly be less dense; this could be reflected in a significantly higher implant failure rate when using machined-surface implants. This would be consistent with the findings of Jaffin and Berman<sup>3</sup> and Friberg and coworkers,<sup>22</sup> who noted an increased failure rate in poor-quality bone when machined-surface implants were placed. In contrast, the results of this study did not find any statistically significant differences in bone types in smokers and non-smokers. Other factors related to delayed wound healing associated with smoking might be present; however, their effects may be clinically insignificant when surface-modified implants are placed.

Based upon the results of this study, it can be speculated that smoking does not appear to play a critical role in achieving osseointegration when utilizing surface-modified implants. However, it should be noted that the study was a retrospective analysis. Furthermore, there was a certain degree of variability with each implant as to whether it was placed immediately after extraction, placed with or without grafting or membrane, the type of healing prosthesis utilized during the healing, and reasons for tooth loss—all of which can play a significant role in the success of osseointegration. In addition, classification of bone type is subjective and could have varied between the 2 operators.

This study focused on the initial osseointegration of implants. Although to the best of the authors' knowledge, all implants placed during the study period that tested successfully to torquing have remained in good health and function, more detailed and long-term studies need to be conducted on the effect of smoking on maintaining osseointegration.

The implications of this study are important, because patients who smoke are at greater risk of dental disease and subsequent tooth loss. If a high implant success rate can routinely be achieved in patients who smoke, they can potentially benefit from this mode of therapy more than from others. Further studies need to be conducted with strict prospective protocols that further elucidate the effects of smoking on osseointegration.

## CONCLUSION

Within the limits of the present study, it can be concluded that smoking does not appear to play a significant role in achieving osseointegration when utilizing surface-modified implants.

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