Smoking and Complications of Onlay Bone Grafts and Sinus Lift Operations

Liran Levin, DMD[1]/Ran Herzberg, DMD[2]/Eran Dolev, DMD[2]/Devorah Schwartz-Arad, DMD, PhD[3]

Purpose: *To compare the incidence of complications related to onlay bone grafts (OBGs) and sinus lift operations (SLOs) among smokers and nonsmokers.* ***Materials and Methods:*** *Data from 143 operations performed during the years 1995 to 2003 were analyzed. There were 64 OBGs and 79 SLOs. Patients were divided into 3 groups: nonsmokers, mild smokers (up to 10 cigarettes per day), and heavy smokers (more than 10 cigarettes per day). Duration of smoking (less or more than 10 years) was recorded. OBG complications were classified as minor (hematoma, swelling, inflammation, or temporary paresthesia) or major (graft exposure or mobility). For the SLO, perforations of the schneiderian membrane were the main intraoperative complication; postoperative complications mostly consisted of swelling, acute or chronic sinus infection, or bleeding.* ***Results:*** *Of smokers having OBG, 50% experienced complications, compared to 23.1% of nonsmokers. Major complications were observed in one third of the smokers, compared to only 7.7% in nonsmokers. There was also a tendency toward complications in former smokers, although this relationship was not statistically significant. There was no relationship between SLO complications and smoking or a past smoking habit.* ***Discussion:*** *In the present study, smokers demonstrated significantly higher postoperative complications following OBG operations. Smoking did not influence the results in the SLO group. There was no statistically significant difference between complications and past smoking. This finding indicates that the risk of complications can be reduced up to the normal nonsmoker complication rate when smoking ceases.* ***Conclusions:*** *This study established a relationship between OBG complications and smoking in this patient population. A higher incidence of complications was found in the smoking group. There was no significant influence of smoking on SLO complications.* INT J ORAL MAXILLOFAC IMPLANTS 2004;19:369–373

Key words: *bone transplantation, complications, dental implants, maxillary sinus, smoking, sinus augmentation*

The use of autologous bone grafts with dental implants was originally described by Brånemark and coworkers in 1975[1] and is now a well-accepted procedure in oral and maxillofacial rehabilitation.[2–5] A sinus lift operation (SLO) has a predictable outcome, with an implant survival rate of over 90% for 3 to 5 years.[6–10] It is considered a safe treatment modality, with only minor complications.[11]

It has long been suspected that cigarette smoking adversely affects wound healing. Arteriolar vasoconstriction and decreased blood flow are seen in response to smoking,[12,13] and toxic byproducts of cigarette smoking, such as nicotine, carbon monoxide, and hydrogen cyanide, have been implicated as risk factors for impaired healing.[14]

Smoking impairs wound healing in various surgical operations. In orthopedic surgery, such as hip or knee arthroplasty, smoking is the single most important risk factor for the development of postoperative complications, particularly those relating to wound healing, cardiopulmonary complications, and postoperative intensive care.[15] Smoking is also associated with an increased risk of complications in patients with open tibial fractures.[16] In dermatology, smoking proved to decrease the synthesis rates of types I and III collagen in skin in vivo and to alter the balance of extracellular matrix turnover in

[1]Clinical Instructor, Department of Restorative Dentistry, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
[2]Clinical Instructor, Department of Prosthodontics, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.
[3]Lecturer and Coordinator, Department of Oral and Maxillofacial Surgery, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel.

Correspondence to: Dr Devorah Schwartz-Arad, Department of Oral and Maxillofacial Surgery, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel. Fax: +972-3-6409250. E-mail: dubish@post.tau.ac.il

skin.[17] Tissue ischemia and wound-healing impairment secondary to the influence of tobacco is problematic for plastic surgeons, especially during elective facial esthetic procedures, cosmetic and reconstructive breast operations, abdominoplasty, free-tissue transfer, and replantation procedures.[18]

In dentistry, smoking compromises healing after mucogingival surgery.[19–22] Smokers exhibit a trend toward a less favorable healing response following flap debridement compared to nonsmokers, as measured by probing depths and clinical attachment levels.[23]

In the oral cavity, an increase in plaque accumulation, a higher incidence of gingivitis and periodontitis, a higher rate of tooth loss, and an increase in resorption of the alveolar ridge have been found among smokers. Bain and Moy[12] assessed the various factors that predisposed implants to failure in 540 patients who received 2,194 Brånemark System implants (Nobel Biocare, Göteborg, Sweden) and found that a significantly greater percentage of failures occurred in smokers than in nonsmokers. Lindquist and associates[24,25] compared marginal bone loss around osseointegrated dental implants among smokers and nonsmokers and found that among smokers with poor oral hygiene, marginal bone loss was nearly 3 times greater than that seen in nonsmokers. Smokers can also suffer detrimental effects around successfully integrated maxillary implants, with a significantly greater Bleeding Index, greater mean peri-implant pocket depth, more frequent peri-implant inflammation, and radiographically greater mesial and distal bone loss.[26]

An association between dental implants placed in augmented maxillary sinuses and history of smoking has been reported.[27] A higher failure rate was found in smokers after rehabilitation of severely resorbed maxillae with and without bone grafts.[28]

The purpose of this study was to compare the incidence of complications related to onlay bone grafts (OBGs) and SLOs among smokers and nonsmokers.

MATERIALS AND METHODS

The study was based on data from 143 operations: 64 OBGs in 56 patients (17 men and 39 women) and 79 SLOs in 72 patients (26 men and 46 women). Information obtained included a complete medical and dental history, with specific emphasis on smoking habits and clinical and radiographic evaluations. Twelve of the OBGs (18.8%) were performed in smokers and 52 (81.3%) were performed in nonsmokers. OBG operations were carried out according to a 2-stage technique; the endosseous implantation was performed 4 to 5 months later. Within the SLO group, 30 (38%) operations were performed in smokers and 49 (62%) were performed in nonsmokers. Of the SLO group, 69.6% (55 operations) involved simultaneous dental implantation. One surgeon performed all operations between the years 1995 and 2003 under sterile conditions, following a protocol described by Schwartz-Arad and coworkers[29] and, with a modification, the operating protocol of Misch.[2] Criteria for accepting patients into the study group were adequate information regarding age, gender, and health status; pre- and postoperative radiographs; and follow-up for at least 6 months postsurgery.

All smoking habits were known at the time of operation. Current smokers were divided into 2 subgroups with regard to the number of cigarettes per day (mild smokers = fewer than 10; heavy smokers = more than 10) and duration of smoking (mild smokers = fewer than 10 years; heavy smokers = more than 10 years). Past smokers were defined as patients who stopped smoking at least 6 months before the surgical procedure.

Smoking and nonsmoking patients were divided into 2 groups: patients with complications and patients without complications. Minor OBG complications were hematoma, swelling, inflammation, and temporary paresthesia; major complications were graft exposure or graft mobility. For the SLO group, perforations of the schneiderian membrane were the main intraoperative complication, and postoperative complications consisted mainly of swelling, acute or chronic sinus infection, or bleeding.

Statistical analysis included the Pearson chi-square test of association and analysis of variance (ANOVA) using BMDP statistical software (SPSS, Chicago, IL).[30]

RESULTS

There was no significant difference in age and gender between the smoking and the nonsmoking groups. There was also no significant difference with respect to gender or medical problems (eg, hypertension, hypotension, hypothyroidism) and complications. However, all 4 diabetic patients experienced complications after bone grafting ($P = .0002$).

Table 1 provides a profile of the smokers included in the study. Table 2 presents the operative complications encountered. Complications following OBG occurred in 23.1% of nonsmokers, compared to 50% of smokers. Major complications took place in one third of the operations in smokers, versus 7.7%

in the nonsmokers ($P = .04$). Table 3 describes major OBG complications according to smoking and diabetes status.

There was also a relationship between complications and past smoking, although this was not statistically significant ($P = .06$).

There was no relationship between SLO complications and smoking or past smoking; this included intraoperative as well as postoperative complications. Perforations of the schneiderian membrane were the main intraoperative complication (37 patients [46.8%]); postoperative complications consisted mostly of swelling (6 patients [7.6%]), acute or chronic sinus infection (4 patients [5.1%]), and bleeding (4 patients [5.1%]) (Table 4).

DISCUSSION

Tobacco use is a significant contributor to preventable morbidity and mortality in the United States.[31] A significant proportion of cardiovascular diseases, various oral and pulmonary neoplasms, nonmalignant respiratory diseases, and peripheral vascular disorders can be attributed to the use of cigarettes. Surgical outcomes can also be adversely affected as a result of cigarette smoking, with intraoperative and postoperative pulmonary, cardiovascular, and cerebrovascular complications, as well as increased wound healing complications. These are found across the entire spectrum of surgical specialties.[14–17] In the dental literature, smoking has been

Table 1 Profile of Smokers in Study

	OBG (%)	SLO (%)
Smokers	12 (18.8)	30 (38.0)
Smoking > 10 cigarettes a day	12 (18.8)	27 (34.2)
Smoking > 10 years	10 (15.6)	26 (32.9)
Past smokers*	27 (42.2)	11 (13.9)

*Past smokers were defined as patients who stopped smoking at least 6 months before the surgical procedure.

Table 2 Complications Encountered in Smokers and Nonsmokers During or After Onlay Bone Grafting and Sinus Lift Operations

Group/ complication	Smokers (%)	Nonsmokers (%)	Total operations (%)
Onlay bone graft*			
None	6 (50.0)	40 (76.9)	46 (71.9)
Minor	2 (16.7)	8 (15.4)	10 (15.6)
Major	4 (33.3)	4 (7.7)	8 (12.5)
Total	12	52	64
Sinus lift			
None	10 (33.3)	18 (36.7)	28 (35.4)
All kinds	20 (66.7)	31 (63.3)	51 (64.6)
Total	30	49	79

*$P < .05$ for smokers and nonsmokers in the "no complications" versus "minor and major complications" groups and for the "no complications" and "minor complications" groups versus the "major complications" group.
Onlay bone graft complications: Hematoma, swelling, inflammation, and temporary paresthesia were considered minor, and graft exposure and graft mobility were considered major.

Table 3 Major Complications Encountered with Onlay Bone Grafting

Patient no.	Graft exposure	Graft removal	Smoker?	Diabetic?
1	No	Yes	Yes	No
2	No	Yes	Yes	No
3	No	Yes	Yes	No
4	Yes	No	No	No
5	Yes	No	No	No
6	Yes	No	No	Yes
7	Yes	No	Yes	Yes
8	Yes	No	No	Yes

Table 4 Complications Encountered with Sinus Lift Operations

Complication	Smokers (%)	Nonsmokers (%)	Total complications (%)
Schneiderian membrane perforation	15 (50.0)	22 (44.9)	37 (46.8)
Swelling	5 (16.6)	1 (2.0)	6 (7.6)
Sinus infection	2 (6.6)	2 (4.0)	4 (5.1)
Bleeding	2 (6.6)	2 (4.0)	4 (5.1)
Total	24	27	51

shown to compromise healing after mucogingival surgery.[18–22] Tobacco use has been associated with oral cancer, periodontal disease, leukoplakia, stomatitis nicotina, and impaired gingival bleeding.[32–34]

It has been shown that smoking causes a higher incidence of complications (spontaneous premature implant exposure) following implant placement.[35] In the present study, smokers demonstrated significantly more frequent postoperative complications following OBG operations.

The influence of smoking was less significant in SLO complications. Kan and coworkers[36] evaluated the effect of smoking on implant success in grafted maxillary sinuses and reported a higher cumulative implant success rate in nonsmokers than in smokers. However, they did not report graft complications, as in the present study.

There was no statistically significant difference between complications and a past history of smoking. This finding indicates that the risk of complications can be reduced up to the normal nonsmoker complication rate when smoking ceases. Numerous smoking cessation protocols have been proposed to improve surgical outcomes in smokers.[37,38]

It is beyond the scope of this article to discuss the possible mechanisms by which smoking increases OBG complications. The present study does not provide any insight into the mechanism associated with complications in smokers; however, it is probable that these relate to any or all factors, such as systemic vasoconstriction, reduced blood flow, increased platelet aggregation, and polymorphonuclear leukocyte dysfunction, that have been identified in smokers.[39–42] Nicotine may have an effect on cellular protein synthesis and its modulation of beta-1 integrin expression and impair gingival fibroblast ability to adhere to and communicate with one another and with the extracellular matrix, thus impairing wound healing and/or exacerbating periodontal disease.[43] The volatile components of cigarette smoke, such as acrolein and acetaldehyde, could have a cytotoxic effect on human gingival fibroblasts, resulting in a loss of capacity for adhesion and proliferation.[44] The consequences of this could be impaired maintenance, integrity, and remodeling of the oral connective tissue.

Smokers undergoing ridge augmentation should be encouraged by their treating clinicians to quit, since it is known that smoking can reduce the chances for success.

Diabetic patients in the present study showed a significantly higher complication rate following OBG. Diabetes is known to increase the risk of infection and delay wound healing.[45] Therefore, this kind of ridge augmentation may not be suitable for diabetic patients. Further research is necessary to find a way to perform this procedure in diabetic patients without the risk of complications.

CONCLUSION

Smokers had a higher incidence of complications after OBG in this patient population. Smoking did not influence the results in the SLO group. Potential patients should be advised that smoking can have a harmful effect on these procedures. The risk of complications may decrease once smoking ceases.

REFERENCES

1. Brånemark P-I, Lindstrom J, Hallen O, Breine U, Jeppson PH, Ohman A. Reconstruction of the defective mandible. Scand J Plast Reconstr Surg 1975;9:116–128.
2. Misch CM. Ridge augmentation using mandibular ramus bone grafts for the placement of dental implants: Presentation of a technique. Pract Periodontics Aesthet Dent 1996;8:127–135.
3. Misch CM. Comparison of intraoral donor sites for onlay grafting prior to implant placement. Int J Oral Maxillofac Implants 1997;12:767–776.
4. Rissolo AR, Bennett J. Bone grafting and its essential role in implant dentistry. Dent Clin North Am 1998;42:91–116.
5. Lynch SE, Genco RJ, Marx R (eds). Tissue Engineering: Applications in Maxillofacial Surgery and Periodontics. Chicago: Quintessence, 1999:83–98.
6. Jensen OT, Shulman LB, Block MS, Iacono VJ. Report of the Sinus Consensus Conference of 1996. Int J Oral Maxillofac Implants 1998;13(suppl):5–45.
7. Kirsch A, Ackermann KL, Hurzeler MB, Hutmacher D. Sinus grafting with porous hydroxyapatite. In: Jensen OT (ed). The Sinus Bone Graft. Chicago: Quintessence, 1999: 79–94.
8. Tong DC, Drangsholt M, Beirne OR. A review of survival rates for implants placed in grafted maxillary sinuses using meta-analysis. Int J Oral Maxillofac Implants 1998;13:175–182.
9. Khoury F. Augmentation of the sinus floor with mandibular bone block and simultaneous implantation: A 6-year clinical investigation. Int J Oral Maxillofac Implants 1999;14: 557–564.
10. Hürzeler MB, Kirsch A, Ackermann KL, Quinones CR. Reconstruction of the severely resorbed maxilla with dental implants in the augmented maxillary sinus: A 5-year clinical investigation. Int J Oral Maxillofac Implants 1996;11: 466–475.
11. Ziccardi VB, Betts NJ. Complications of maxillary sinus augmentation. In: Jensen OT (ed). The Sinus Bone Graft. Chicago: Quintessence, 1999:201–208.
12. Bain CA, Moy PK. The association between the failure of dental implants and cigarette smoking. Int J Oral Maxillofac Implants 1993;8:609–615.
13. Misch CE, Scoretecci GM, Benner KU (eds). Implants and Restorative Dentistry. London: Duntz, 2001:144–145.
14. Silverstein P. Smoking and wound healing. Am J Med 1992;93(suppl 1A):22–24.

15. Møller AM, Pedersen T, Villebro N, Munksgaard A. Effect of smoking on early complications after elective orthopaedic surgery. J Bone Joint Surg Br 2003;85:178–181.
16. Adams CI, Keating JF, Court-Brown CM. Cigarette smoking and open tibial fractures. Injury 2001;32:61–65.
17. Knuutinen A, Kokkonen N, Risteli J, et al. Smoking affects collagen synthesis and extracellular matrix turnover in human skin. Br J Dermatol 2002;146:588–594.
18. Krueger JK, Rohrich RJ. Clearing the smoke: The scientific rationale for tobacco abstention with plastic surgery. Plast Reconstr Surg 2001;108:1063–1073.
19. Haas R, Mensdorff-Pouilly N, Watzek G. Kaplan-Meier vergleichsanalysen von 3000 gesetzten implantaten. In: Gesellschaft für orale Implantologie (eds). Jahrbuch Fur Orale Implantologie. Berlin: Quintessenz, 1994:213–225.
20. Hutton JE, Heath MR, Chai JY, et al. Factors related to success and failure rates at 3-year follow-up in a multicenter study of overdentures supported by Brånemark implants. Int J Oral Maxillofac Implants 1995;10:33–42.
21. Bergstrom G, Floderus-Myrhed B. Co-twin control study of the relationship between smoking and some periodontal disease factors. Community Dent Oral Epidemiol 1983;11: 113–116.
22. Krall EA, Dawson-Hughes B, Garvey AJ, Garcia RI. Smoking, smoking cessation and tooth loss. J Dent Res 1997; 76:1653–1659.
23. Scabbia A, Cho KS, Sigurdsson TJ, Kim CK, Trombelli L. Cigarette smoking negatively affects healing response following flap debridement surgery. J Periodontol 2001;72: 43–49.
24. Lindquist LW, Carlsson GE, Jemt T. Association between marginal bone loss around osseointegrated mandibular implants and smoking habits: A 10-year follow-up study. J Dent Res 1997;10:1667–1674.
25. Lindquist LW, Carlsson GE, Jemt T. A prospective 15-year follow-up study of mandibular fixed prostheses supported by osseointegrated implants. Clin Oral Implants Res 1996;7: 329–336.
26. Haas R, Haimbock W, Mailath G, Watzek G. The relationship of smoking on peri-implant tissue: A retrospective study. J Prosthet Dent 1996;76:592–596.
27. Olson JW, Dent CD, Morris HF, Ochi S. Long-term assessment (5 to 71 months) of endosseous dental implants placed in the augmented maxillary sinus. Ann Periodontol 2000;5: 152–156.
28. Widmark G, Andersson B, Carlsson GE, Lindvall AM, Ivanoff CJ. Rehabilitation of patients with severely resorbed maxillae by means of implants with or without bone grafts: A 3- to 5-year follow-up clinical report. Int J Oral Maxillofac Implants 2001;16:73–79.
29. Schwartz-Arad D, Herzberg R, Dolev E. The prevalence of surgical complications of the sinus graft procedure and its impact on implant survival. J Periodontol (in press).
30. Dixon WJ (ed). BMDP Statistical Software. San Francisco, CA: University of California Press, 1993.
31. Centers for Disease Control and Prevention. Tobacco use: United States, 1900–1999. Morbid Mortal Wkly Rep 1999; 48:986.
32. Christen AG. The impact of tobacco use and cessation on oral and dental diseases and conditions. Am J Med 1992; 93:25–31.
33. Bergstrom J, Eliasson S. Noxious effect of cigarette smoking on periodontal health. J Periodontal Res 1987;22:513–517.
34. Haber J, Wattles J, Crowley M, Mandell R, Joshipura K, Kent RL. Evidence for cigarette smoking as a major risk factor for periodontitis. J Periodontol 1993;64:16–23.
35. Schwartz-Arad D, Samet N, Samet N, Mamlider A. Smoking and complications of endosseous dental implants. J Periodontol 2002;73:153–157.
36. Kan JY, Rungcharassaeng K, Lozada JL, Goodacre CJ. Effects of smoking on implant success in grafted maxillary sinuses. J Prosthet Dent 1999;82:307–311.
37. Bain CA. Smoking and implant failure: Benefits of a smoking cessation protocol. Int J Oral Maxillofac Implants 1996; 11:756–759.
38. Miller PD Jr. Root coverage using the free soft tissue autograft following citric acid application. Int J Periodontics Restorative Dent 1985;5:15–37.
39. Cryer P, Haymond MW, Santiago JV, Shah SD. Norepinephrine and epinephrine release and androgenic mediation of smoking associated homodynamic and metabolic events. N Engl J Med 1976;295:573–577.
40. Sarine CL, Austin JC, Nickel WO. Effects of smoking and digital blood flow volume. J Am Med Assoc 1974;229:1327–1328.
41. MacFarlane GD, Herzberg MC, Wolff LF, Hardie NA. Refractory periodontitis associated with abnormal polymorphonuclear leukocyte phagocytosis and cigarette smoking. J Periodontol 1992;63:908–913.
42. Noble RC, Penny BB. Comparison of leukocyte count and function in smoking and non-smoking young men. Infect Immunol 1975;12:550–555.
43. Snyder HB, Caughman G, Lewis J, Billman MA, Schuster G. Nicotine modulation of in vitro human gingival fibroblast beta-1 integrin expression. J Periodontol 2002;73:505–510.
44. Poggi P, Rota MT, Boratto R. The volatile fraction of cigarette smoke induces alterations in the human gingival fibroblast cytoskeleton. J Periodontal Res 2002;37:230–235.
45. Little JW, Falace DA, Miller CS, Rhodus NL (ed). Dental Management of the Medically Compromised Patient, ed 5. St Louis: Mosby, 1997:387–409.