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Short communication

The effect of smoking on early implant failure

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This retrospective study describes the effect of smoking on initial fixture failure before functional loading with fixed prosthetic restorations. Of 208 installed Brånemark fixtures in the mandible, only 1 failed (0.5%), and no detrimental effect of smoking on fixture survival could be detected. In the maxilla, 10/244 fixtures failed (4%); 7/78 fixtures failed in smokers and 3/166 in nonsmokers. The failure rate before loading was 9% in smokers versus 1% in nonsmokers and was statistically significant, despite the fact that bone quality in both groups was comparable. Failed fixtures occurred in 31% of the smokers, despite often excellent bone quality, long fixture length or good initial stability. Only 4% of the nonsmokers had failures, in most cases related to poor bone quality. It is concluded that smoking is a significant although not the only important factor in the failure of implants prior to functional loading. Prospective studies are needed to assess the risk of implant failure in conjunction with smoking. In the mean time, patients should be informed of the adverse effect of smoking.

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It is well known that smoking may contribute to lung cancer and cardiovascular disease. In the oral cavity, smoking is a risk factor in alveolar bone loss around teeth, even in subjects with a high standard of oral hygiene (Bergström & Eliasson 1987). Moreover, smoking is associated with a less favorable outcome after periodontal surgery (Preber & Bergström 1990). Cigarette smoking was observed to induce impaired wound healing, leading to bone loss or implant loss, in a group of patients undergoing bone grafting in conjunction with implant placement (Jones & Triplett 1992). Bain & Moy (1993) demonstrated a significant association between cigarette smoking and the failure rate of Brånemark fixtures in a group of 540 patients with nearly 2200 loaded implants. In their report, the absolute failure rate in the maxilla was 18% in smokers versus 7% in nonsmokers. In the mandible the difference was 5% versus 2%. As the results were not presented cumulatively, it is impossible to discriminate between early failures before loading or failures due to loading conditions or peri-implantitis.

The aim of this retrospective study is to describe the survival of Brånemark fixtures installed in a periodontal clinic in relation to the smoking habits of the patient. The article focuses on failures encountered between fixture installation and initial functional loading with fixed prosthetic restorations.

Material and methods

Patient selection

All patients were referred by general dentists and selected for the implant procedure after answering a medical and dental checklist regarding current and previous disease and medication.

Smoking habits were asked for but not used as an exclusion criterion. A standard radiological examination was performed on each patient with detailed apical radiographs and orthopantomographs. Computerized tomography was included in the maxillary cases to allow presurgical estimation of bone quantity and anatomic features. The clinical protocol of the implant-prosthetic procedure followed in the clinic has been described previously (De Bruyn et al. 1992). All patients were treated by the same surgeon (HDB), who determined bone quality and quantity for each fixture site during installation (according to Lekholm & Zarb, 1985). Information regarding medical history, smoking

Table 1. Distribution of smoking (S) and nonsmoking (NS) subjects according to jaw, smoking habit, gender and age at the time of fixture placement. Patients with failures are indicated between brackets.

	Age (years)						
	21–30	31–40	41–50	51–60	61–70	71–80	mean (range)
Upper jaw							
NS women	2	4 (1)	3	10	3	2	51.1 (28–76)
S women	1	1	3 (1)	–	2 (1)	–	49.0 (28–70)
NS men	2	1	3	7 (1)	7	1	52.0 (20–71)
S men	–	1	3 (2)	5 (1)	–	–	49.8 (35–59)
Total	5	7 (1)	12 (3)	22 (2)	12 (1)	3	51.0 (20–76)
Lower jaw							
NS women	–	2	7	12 (1)	5	4	56.1 (35–75)
S women	–	–	3	2	–	–	53.4 (43–70)
NS men	–	2	4	3	6	1	56.3 (35–80)
S men	–	–	3	2	–	–	47.4 (42–52)
Total	–	4	17	19 (1)	11	5	55.1 (35–80)

Student's *t*-test showed no difference in age between groups.

habit, fixture position, fixture type, bone quantity and bone quality was submitted to the Nobelpharma Follow-up System in Göteborg, Sweden. The present retrospective study is based on the information retrieved from that system.

Fixture failure

Fixtures were counted as failures when removed because of clinical mobility. Failure rates are expressed cumulatively (Quirynen et al. 1991) per 6-month interval for smokers and nonsmokers.

Results and discussion

In total, 462 Brånemark fixtures (Nobelpharma AB, Göteborg, Sweden) were installed consecutively in 117 patients by the same periodontist (HDB); 452 implants were exposed for abutment connection when preparing this study. The distribution of subjects according to age, gender and smoking habits is given in Table 1. No statistically significant difference in age was found between smokers and nonsmokers. Failures did not seem to be related to gender or age.

Table 2. Fixture loss in smoking and nonsmoking patients for upper and lower jaw before loading (between fixture installation and connection of prosthesis). Chi-square test is performed for statistical analysis.

	Smokers	$P(\chi^2)$	Nonsmokers	Total failure
Lower jaw				
Fixtures	0/36	NS	1/172	1/208 (0.5%)
Patients	0/10	NS	1/46	1/56 (2%)
Upper jaw				
Fixtures	7/78	<0.01	3/166	10/244 (4%)
Patients	5/16	<0.01	2/45	7/61 (11%)

Especially in women, age is related to hormonal changes, increasing osteoporosis. Failures occurred in patients from 39 to 64 years old and were proportionally equally distributed between men and women. We could not find more implant losses in elderly women, although they are more susceptible to osteoporosis. This is in agreement with Dao et al. (1993).

The number of fixtures lost before loading (from implant surgery to connection of prosthetic restoration) is given in Table 2.

In the mandible, 1/208 fixtures was lost at abutment connection but none was lost after loading. In the maxilla 10/244 fixtures were removed in the period between fixture installation and prosthetic connection. One fixture was lost shortly after implantation, 8 fixtures were lost at abutment connection and one during the healing phase, before the prosthesis was connected. The total absolute failure rates of 0.5% in the mandible and 4% in the maxilla before prosthetic functioning are comparable with results obtained in other centers (Albrektsson 1988; Quirynen et al. 1991). This indicates that the success rates for fixtures installed in a periodontal clinic are similar to those installed under hospital conditions. In the mandible, smoking habits do not appear to affect the failure rate. In the maxilla, however, the initial fixture failure rate is significantly higher in smokers (9%) than nonsmokers (1%), and 31% of the smoking patients encountered fixture failure versus only 4% of the nonsmokers. This suggests that smoking is an important factor for the prognosis of osseointegration.

Earlier Bain & Moy (1993) presented similar conclusions in a group of 540 patients with an absolute failure percentage of 18% in smokers versus 7% in nonsmokers in the maxilla. Unfortunately,

Table 3. Description of fixtures lost in smoking and nonsmoking patients, before and after loading.

Patient			Fixture		Bone	
number	sex	age (years)	position	length	type*	Failure time
Fixture loss in nonsmoking patients (n=91)						
17	male	52	24	10 mm×3.75	A2	abutment
21	female	66	12	13 mm×3.75	B4	5 months in function
49	female	59	43	13 mm×3.75	C1	abutment
70	female	39	24	7 mm×4.0	E2	abutment
			21	7 mm×4.0	E2	healing abutment
Fixture loss in smoking patients (n=26)						
16	male	45	22	10 mm×3.75	E3	1 month after surgery
			11	13 mm×3.75	C3	abutment
			13	13 mm×3.75	C3	11 months in function
			24	10 mm×3.75	E3	11 months in function
64	male	43	22	13 mm self-tapping	A2	abutment
			11	15 mm×4.0	A2	abutment
65	male	56	12	13 mm×3.75	B1	abutment
			24	7 mm×4.0	B1	10 months in function
88	female	64	13	10 mm×4.0	D3	abutment
101	female	47	21	13 mm×3.75	A2	abutment

* According to Lekholm & Zarb (1985)

Table 4. Cumulative failure rates for the upper jaw in smoking and nonsmoking patients. Chi-square test is performed for statistical analysis.

	Smokers failure	%	P (χ^2)	Nonsmokers failure	%
Before abutment	1/78	1.28	<0.01	0/166	0.0
Abutment	6/77	8.97	<0.01	2/166	1.20
0-6 months	0/71	8.97	<0.05	2/162[b]	2.42
6-12 months	3/55[a]	13.94	<0.001	0/131	2.42
12-18 months	0/41	"		0/91	"
18-24 months	0/20	"		0/62	"
24-30 months	0/20	"		0/35	"
30-36 months	0/20	"		0/3	"

Withdrawn from total number: [a]1 patient with 6 fixtures did not come for recall and [b]2 sleeping fixtures.

they did not calculate their failures cumulatively and only absolute failure percentages are given, pertaining to a functioning period ranging between 1 and 83 months. It is thus impossible to discriminate between failures before loading and failures due to peri-implantitis or overloading. In our study the absolute failure rate is 13% in smokers and 2% in nonsmokers in a functioning period of 3-36 months. The failure rate is smaller than the results presented by Bain & Moy (1993), probably due to the longer functioning period, explaining why more fixtures can be lost for other reasons than smoking alone.

A detailed description of the failed fixtures is given in Table 3, including fixtures that failed after loading.

Although it does not fall within the scope of this article, the cumulative failure rates in the maxilla were calculated for smokers and nonsmokers per 6-month interval (Table 4). The significant difference between both groups just prior to functional loading (interval 0-6 months) increases with time. After 1 year (12- to 18-month interval), the difference of 14% and 2% was highly significant (P<0.001). It is, however, impossible to attribute the growing failure rates to smoking habits alone, as more uncontrolled and unknown parameters may very well play an additional role in implant failure.

We also lack precise information about the smoking habits after fixture installation and we do not have scientifically sound information about the oral hygiene level of the patients. Multifactorial reasons such as loading conditions, parafunctions and oral hygiene level play a role in the long-term prognosis. It is also known that smoking promotes the progression of periodontal disease, affects the microflora and alters the inflammatory response (Akef et al. 1992).

Jawbone quality and quantity were measured for

Table 5. Distribution of jawbone quality and quantity (according to Lekholm & Zarb 1985) measured at installation of upper jaw fixtures in smokers and nonsmokers.

	Smokers		Nonsmokers	
	installed	lost	installed	lost
Quality				
1	7	1	31	0
2	33	3	51	3
3	18	3	33	0
4	20	0	51	0
Quantity				
A	33	3	56	1
B	10	1	62	0
C	26	0	34	0
D	5	1	8	0
E	4	2	6	2
Total	78	7	166	3

The chi-square test showed a favorable jawbone quantity ($P<0.01$) in nonsmokers but no difference in jawbone quality between smokers and nonsmokers.

each fixture site during surgery, and the distribution is described for both groups in Table 5. Statistical analysis revealed no difference in jawbone quality between the smoking and nonsmoking group. However, there was a more favorable bone quantity in the nonsmokers. We have no explanation for this phenomenon. Some association has been observed between failure rate and fixture length, which reflects to a certain extent the bone volume. Since we instead lost long fixtures in the smoking group, we believe that bone mass is not the most decisive factor in prognosis of initial implant survival. Bone quality is believed, however, to be more important than quantity in terms of prognosis for osseointegration (van Steenberghe et al. 1990; Bass & Triplett 1991). As far as bone quality is concerned, the smoking group is statistically comparable with the nonsmoking group. We therefore believe that the results of the groups can be compared.

A higher ($P<0.01$) fixture loss (9%) was found in the smoking group despite good bone quality (1 or 2 according to Lekholm & Zarb 1985) or favorable bone quantity (A or B according to Lekholm & Zarb 1985).

Some of the lost fixtures were self-tapping or 4 mm wide, and one would not expect to lose them (Quirynen et al. 1991). Smokers seem to be prone to multiple fixture losses (Table 3). Our data lead to the conclusion that the rate of initial implant failure is higher in smokers irrespective of bone quantity or quality. To date, one can only speculate as to the precise mechanism for this increased failure rate. In the literature, however, nicotine is described as inducing a systemic vasoconstriction, changes in blood flow velocity, changes in plasma composition and compromised neutrophil function. These adverse effects are suggested to compromise the healing and to give a higher risk of infection in smokers (Bain & Moy 1993).

Conclusion

From the data obtained retrospectively in our study, it is impossible to assess precisely the risk of implant failure in conjunction with smoking. Other possible risk factors have to be identified. Preliminary, we can only conclude that smoking has an adverse effect on initial implant survival before functional loading. Patients should be warned of this detrimental effect, and a protocol of cessation of smoking should be advised. A possible detrimental effect of smoking on the long-term survival of loaded implants cannot be excluded but remains to be investigated more thoroughly by means of well-controlled prospective studies, taking into consideration other factors influencing implant failure.

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Résumé

Dans cette étude rétrospective est décrit l'effet du tabagisme sur l'échec initial de l'implant avant toute charge prothétique. Sur 208 implants *ad modum* Brånemark® fixés dans la mandibule, seulement un a raté (0,5%) et aucun effet négatif du tabagisme sur la survie de l'implant n'a pu être détecté. Dans le maxillaire dix implants sur 244 ont subi un échec (4,1%): sept sur 78 n'ont pas réussi chez les fumeurs et trois sur 168 chez les non-fumeurs. Le taux d'échec avant charge prothétique était de 8,9% chez les fumeurs et de 1,2% chez les non-fumeurs et avait une différence significative bien que la qualité de l'os était comparable dans les deux groupes. L'échec des implants se produsait chez 31% des fumeurs malgré une qualité osseuse souvent excellente, un implant de bonne longueur et une bonne stabilité initiale. Seuls 4% des non-fumeurs accusaient des échecs qui étaient la plupart du temps en relation avec la pauvre qualité osseuse. Le tabagisme est donc un facteur significatif important, mais pas le seul, dans l'échec des implants avant la charge fonctionnelle. Des études prospectives sont nécessaires pour estimer le risque d'échec implantaire en association avec le tabagisme. En attendant, le patient devrait être informé des effets négatifs du tabagisme.

Zusammenfassung

In dieser retrospektiven Untersuchung wird der Effekt des Rauchens auf Frühmisserfolge, welche auftraten, bevor die Implan-

tate durch fixe Rekonstruktionen belastet wurden, beschrieben. Unter 208 im Unterkiefer gesetzten Brånemark Implantaten trat nur ein Misserfolg auf (0.48%) und es konnte kein nachteiliger Effekt des Rauchens auf die Implantatüberlebensrate entdeckt werden. Im Oberkiefer traten unter 244 Implantaten 10 Misserfolge auf (4.10%). Bei Rauchern versagten 7 von 78 Implantaten und bei Nichtrauchern 3 von 166. Die Misserfolgsrate vor Belastung betrug bei Rauchern 8.9%, während sie bei Nichtrauchern 1.2% betrug. Der Unterschied war statistisch signifikant, obwohl die Knochenqualität in beiden Gruppen vergleichbar war. Misserfolge traten bei 31% der Raucher trotz der oft ausgezeichneten Knochenqualität, der Verwendung langer Implantate und der guten Primärstabilität auf. Nur 4% der Nichtraucher zeigten Misserfolge, meist in Zusammenhang mit schlechter Knochenqualität. Es wurde daraus gefolgert, dass das Rauchen einen entscheidenden, wenn auch nicht den einzigen wichtigen Faktor bezüglich Implantatmisserfolgen vor funktioneller Belastung darstellt. Prospektive Untersuchungen sind nötig, um das Risiko eines Implantatmisserfolges im Zusammenhang mit Rauchen einschätzen zu können. In der Zwischenzeit sollten die Patienten über die Nebeneffekte des Rauchens informiert werden.

Resumen

En este estudio retrospectivo se describe el efecto del tabaco sobre los fracasos iniciales de los implantes, antes de que se carguen funcionalmente con protesis fija. De 208 implantes Brånemark instalados en la mandibula, solo uno falló (0.48%) y no se pudo detectar ningún efecto detrimente del tabaco. En el maxilar fallaron 10/244 implantes (4.10%); 7/78 implantes fallaron en fumadores y 3/166 en no fumadores. El indice de fallos antes de ser cargados fué de 8.9% en fumadores frente a 1.2% en no fumadores y fué estadisticamente significativa, a pesar del hecho de que la calidad del hueso en ambos grupos era comparable. Ocurrieron fracasos en los implantes en 31% de los fumadores, a pesar de una buena calidad habitual del hueso, alta longitud del implante ó buena estabilidad inicial. Se llega a la conclusión de que fumar es un factor significativo aunque no el único importante en el fracaso de implantes previa a su carga funcional. Se necesitan estudios prospectivos para valorar el riesgo de fracaso de los implantes en conjunción con el tabaco. Entre tanto los pacientes deberian ser informados de los efectos del tabaco.

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