Smoking and Flap Survival

Le tabagisme et la survie des lambeaux

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Abstract

Purpose: The aim of this study was to compare the complications of flap surgery in non-smokers and smokers and to determine how the incidence of complications was affected by the abstinence period from smoking before and after flap surgery. **Methods:** In PubMed and Scopus, terms “smoking” and “flap survival” were used, which resulted in 113 papers and 65 papers, respectively. After excluding 6 duplicate titles, 172 titles were reviewed. Among them, 45 abstracts were excluded, 20 full papers were reviewed, and finally 15 papers were analyzed. **Results:** Post-operative complications such as flap necrosis ($P < .001$), hematoma ($P < .001$), and fat necrosis ($P = .003$) occurred significantly more frequently in smokers than in non-smokers. The flap loss rate was significantly higher in smokers who were abstinent for 24 hours post-operatively than in non-smokers ($n = 1464$, odds ratio [OR] = 4.885, 95% confidence interval [CI] = 2.071-11.524, $P < .001$). The flap loss rate was significantly lower in smokers who were abstinent for 1 week post-operatively than in those who were abstinent for 24 hours post-operatively ($n = 131$, OR = 0.252, 95% CI = 0.074-0.851, $P = .027$). No significant difference in flap loss was found between non-smokers and smokers who were abstinent for 1 week preoperatively ($n = 1519$, OR = 1.229, 95% CI = 0.482-3.134, $P = .666$) or for 4 weeks preoperatively ($n = 1576$, OR = 1.902, 95% CI = 0.383-2.119, $P = .812$). **Conclusion:** Since smoking decreases the alveolar oxygen pressure and subcutaneous wound tissue oxygen, and nicotine causes vasoconstriction, smokers are more likely to experience flap loss, hematoma, or fat necrosis than non-smokers. Preoperative and post-operative abstinence period of at least 1 week is necessary for smokers who undergo flap operations.

Résumé

Objectif : La présente étude visait à comparer les complications des opérations par lambeau chez les non-fumeurs et les fumeurs et à déterminer l'effet d'une période d'abstinence du tabagisme avant et après l'opération par lambeau sur l'incidence de complications. **Méthodologie :** Dans PubMed et Scopus, les chercheurs ont utilisé les termes *smoking* ET *flap survival* et extrait 113 articles et 65 articles, respectivement. Après avoir exclu six articles dédoublés, ils ont examiné 172 titres et ont exclu 45 résumés. Ils ont révisé 20 articles complets et analysé 15 articles. **Résultats :** Les complications postopératoires comme la nécrose du lambeau ($P < 0,001$), l'hématome ($P < .001$) et la nécrose graisseuse ($P = 0,003$) étaient considérablement plus fréquentes chez les fumeurs que chez les non-fumeurs. Le taux de perte du lambeau était significativement plus élevé chez les fumeurs qui s'étaient abstenus de fumer 24 heures après l'opération que chez les non-fumeurs ($n = 1464$, rapport de cotes [RC] = 4,885, intervalle de confiance [IC] à 95 % = 2,071 à 11,524, $P < 0,001$). Le taux de perte du lambeau était considérablement plus faible chez les fumeurs abstinents pendant une semaine après l'opération que chez ceux qui l'avaient été seulement 24 heures ($n = 131$, RC = 0,252, IC à 95 % = 0,074 à 0,851, $P = 0,027$). Les chercheurs n'ont constaté aucune différence significative de perte du lambeau entre les non-fumeurs et les fumeurs qui étaient abstinents une semaine avant l'opération ($n = 1519$, RC = 1,229, IC 95 % = 0,482 à 3,134, $P = 0,666$) ou quatre semaines avant l'opération ($n = 1576$, RC = 1,902, IC 95 % = 0,383 à 2,119, $P = 0,812$). **Conclusion :** Puisque le tabagisme réduit la pression de l'oxygène dans les alvéoles et dans les tissus mous des lésions sous-cutanées et que la nicotine est responsable d'une vasoconstriction, les fumeurs sont plus susceptibles que les non-fumeurs de présenter une perte

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du lambeau, un hématome ou une nécrose graisseuse. Chez les fumeurs, une période d'abstinence d'au moins une semaine s'impose avant et après les opérations par lambeau.

Keywords

smoking, surgical flaps, post-operative complications, hematoma, fat necrosis, meta-analysis

Introduction

The deleterious effects of smoking on wound healing have been widely documented.¹ Rohrich stated that plastic surgery patients should be advised to quit smoking 4 weeks prior to a surgical procedure, especially if the procedure requires the undermining of skin flaps.²

However, very few papers have assessed the non-smoking period before and after flap surgery. The aim of this study was to compare the complications of flap surgery in non-smokers and smokers and to systematically characterize the effect of the non-smoking period before and after flap surgery.

Methods

The search terms “smoking” and “flap survival” were used in a PubMed and Scopus search, which resulted in 113 papers and 65 papers, respectively. After excluding 6 duplicate titles, 172

titles were reviewed. Among the 172 titles, 107 titles were excluded, while 65 titles met our inclusion criteria (“smoking” and “flap survival” appeared in the title). Studies that did not discuss smoking and flap survival were excluded. Using these exclusion criteria, 45 abstracts were excluded and 20 full papers discussing smoking and flap survival were reviewed. Of these 20 full papers, 9 papers were excluded because they did not have sufficient content (2 studies) or had non-original content (7 studies), and 4 papers were added from the references of the articles identified in the searches. Ultimately, 15 studies were analyzed (Figure 1).³⁻¹⁷ We followed “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” guidelines in this study.¹⁸

Studies that did not evaluate the effect of smoking on flap survival or microvascular anastomosis were excluded. No restrictions on language and publication forms were imposed. All the articles were read by 2 independent reviewers who extracted the data from the articles.

Figure 1. Selection process of the papers included in this study.

Table 1. Rate of Flap Loss in Patients With or Without Smoking History.

Author	Year	Area	Flap Name	With Smoking History			No Smoking History			P
				N	n	%	N	n	%	
Reus et al ³	1990	Cancer, trauma	Free flap	93	5	5.4	51	3	5.9	
Macnamara et al ⁴	1994	Head and neck	Radial fasciocutaneous, fibula	20	2	10.0	40	4	10.0	
Kinsella et al ⁵	1995	Facial skin	Transpositional, island flap	38	8	21.0	478	7	1.5	
Kroll et al ⁶	1996	Head and neck, breast	RAFF, jejunum, FTRAM	309	26	8.4	342	20	5.8	
Chang et al ⁷	2000	Breast	TRAM	90	11	12.2	41	3	7.3	
Maffi and Tran ⁸	2001	Traumatic wound	LD, gracilis, serratus	28	4	14.3				
Valentini et al ⁹	2008	Head and neck	Iliac crest, radial forearm	77	2	2.6	41	4	9.8	
Little et al ¹⁰	2009	Nose	Forehead flap	48	6	12.5	157	5	3.2	
Herold et al ¹¹	2011	Upper/lower extremity, trunk	LD, ALT, DIEP	17	1	5.9	132	9	6.8	
Köse et al ¹²	2011	Lower extremity	Extended reverse sural A. flap	2	0	0	8	1	12.5	
Paddack et al ¹³	2012	Nose	NLF, PMFF	56	5	8.9	51	1	2.0	
Huang et al ¹⁴	2012	Forehead and temple	Extended DPCF	4	1	25.0	7	0	0	
Oh et al ¹⁵	2012	Diabetic foot	ALT, SCIP, AMT	38	4	10.5	78	6	7.7	
Total				820	75	9.1	1426	63	4.4	<.001

Abbreviations: A, artery; ALT, anterolateral thigh; AMT, anteromedial thigh; DIEP, deep inferior epigastric artery perforator; DPCF, deep-plane cervicofacial; FTRAM, free transverse rectus abdominis myocutaneous flap; LD, latissimus dorsi; N, total patients; n, number of flap loss; NLF, nasolabial flap; PMFF, paramedian forehead interpolation flap; RAFF, rectus abdominis free flap; SCIP, superficial circumflex iliac artery; TRAM, transverse rectus abdominis myocutaneous.

The data were summarized, and a statistical analysis was performed using IBM SPSS version 20 (IBM Corp, Armonk, New York). The patients were classified as non-smokers (without a history of smoking) and smokers (with a history of smoking). Differences between the 2 groups were compared using the independent 2-sample *t* test.

In order to analyze the abstinence periods, non-smokers, 24-hour abstinent smokers, 1-week abstinent smokers, 4-week abstinent smokers, and 1-year abstinent smokers were grouped preoperatively and post-operatively. The odds ratio (OR), 95% confidence interval (CI), and *P* value were calculated.

Results

Among the 15 studies analyzed, 8 were level 2 studies and 7 were level 3 studies. No systematic review or meta-analysis was found (Supplement Data).

Flap Loss

Among 2246 patients from 13 studies, 138 (6.1%) cases of flap necrosis were reported.³⁻¹⁵ A total of 1426 patients from 12 studies^{3-7,9-15} were non-smokers and 820 patients from 13 papers³⁻¹⁵ were smokers. Flap necrosis occurred significantly more frequently in smokers (9.1%, 75/820 patients) than in non-smokers (4.4%, 63/1426 patients, *P* < .001 [independent 2-sample *t* test]; Table 1).

Flap loss according to the preoperative abstinence period. No significant differences were found between non-smokers and smokers who were abstinent for 1 week preoperatively (*n* = 1519, OR = 1.229, 95% CI = 0.482-3.134, *P* = .666), 4 weeks preoperatively (*n* = 1576, OR = 1.902, 95% CI = 0.383-2.119, *P* = .812), or 1 year preoperatively (*n* = 1438, OR = 1.967,

Table 2. Comparison of Flap Loss According to Preoperative and Post-Operative Abstinence.

Pre and Postoperative Abstinence Periods		Flap Loss			OR/ (95% CI)	P Value
		+	-	Total		
Preoperative	1-week abstinence	5	88	93	1.229	.666
	Non-smoker	63	1363	1426	(0.482-3.134)	
	4-week abstinence	6	144	150	1.902	.812
	Non-smoker	63	1363	1426	(0.383-2.119)	
	1-year abstinence	1	11	12	1.967	.520
	Non-smoker	63	1363	1426	(0.250-15.473)	
	4-week abstinence	6	144	150	0.733	.617
	1-week smoker	5	88	93	(0.217-2.474)	
	1-year abstinence	1	11	12	2.182	.488
	4-week smoker	6	144	150	(0.241-19.771)	
Post-operative	24-hour abstinence	7	31	38	4.885	<.001
	Non-smoker	63	1363	1426	(2.071-11.524)	
	1-week abstinence	5	88	93	1.229	.666
	Non-smoker	63	1363	1426	(0.482-3.134)	
	1-week abstinence	5	88	93	0.252	.027
	24-hour abstinence	7	31	38	(0.074-0.851)	

Abbreviations: CI, confidence interval; OR, odds ratio.

95% CI = 0.250-15.473, *P* = .520). No significant difference was found between smokers who were abstinent for 1 week preoperatively and those who were abstinent for 4 weeks

Table 3. Hematoma Formation in Patients With or Without Smoking History.

Author	Year	Area	Flap Name	With Smoking History			Without Smoking History			P
				Pt	H	%	Pt	H	%	
Reus et al ³	1990	Cancer, trauma	Free flap	93	5	5.4	51	1	2.0	
Kinsella et al ⁵	1995	Facial skin	Transpositional, island flap	38	2	5.3	41	3	7.3	
Chang et al ⁷	2000	Breast	TRAM	90	6	6.7	478	8	1.7	
Vandersteen et al ¹⁶	2013	Head and neck	Radial forearm, ALT, fibula	258	31	12.0				
Total				479	44	9.2	570	12	2.1	<.001

Abbreviations: ALT, anterolateral thigh; H, number of hematoma; Pt, total patients; TRAM, transverse rectus abdominis myocutaneous.

preoperatively (n = 243, OR = 0.733, 95% CI = 0.217-2.474, $P = .617$). Likewise, no significant difference was found between smokers who were abstinent for 4 weeks preoperatively and those who were abstinent for 1 year preoperatively (n = 162, OR = 2.182, 95% CI = 0.241-19.771, $P = .488$; Table 2).

Flap loss according to the post-operative abstinence period. The flap loss rate was significantly higher in smokers who were abstinent for 24 hours post-operatively than in non-smokers (n = 1464, OR = 4.885, CI = 2.071-11.524, $P < .001$; Table 2). The flap loss rate was significantly lower in smokers who were abstinent for 1 week post-operatively than in those who were abstinent for 24 hours post-operatively (n = 131, OR = 0.252, 95% CI = 0.074-0.851, $P = .027$). However, no significant difference was found between non-smokers and smokers who were abstinent for 1 week post-operatively (n = 1519, OR = 1.229, 95% CI = 0.482-3.134, $P = .666$; Table 2).

Hematoma

Among 1049 patients from 4 papers, 56 (5.3%) cases of hematoma were reported.^{3,5,7,16} Of these patients, 570 (from 3 papers)^{3,5,7} were non-smokers and 479 (from 4 papers)^{3,5,7,16} were smokers. Hematoma formation occurred significantly more frequently in the smokers (9.2%, 44/479 patients) than in non-smokers (2.1%, 12/570 patients, $P < .001$ [independent 2-sample t test]; Table 3).

Hematoma according to the preoperative abstinence period. No significant differences were found between non-smokers and smokers who were abstinent for 1 week preoperatively (n = 663, OR = 2.642, 95% CI = 0.909-7.681, $P = .074$), 4 weeks preoperatively (n = 720, OR = 1.938, 95% CI = 0.715-5.251, $P = .194$), or 1 year preoperatively (n = 582, OR = 4.227, 95% CI = 0.505-35.413, $P = .184$; Table 4). No significant difference was found between smokers who were abstinent for 1 week preoperatively and those who were abstinent for 4 weeks preoperatively (n = 243, OR = 0.733, 95% CI = 0.217-2.474, $P = .617$). Likewise, no significant difference was found between smokers who were abstinent for 4 weeks preoperatively and those who were abstinent for 1 year preoperatively (n = 162, OR = 2.182, 95% CI = 0.241-19.771, $P = .488$).

Table 4. Comparison of Hematoma According to Preoperative and Post-Operative Abstinence.

Pre and Postoperative Abstinence Periods		Hematoma			OR/(95% CI)	P Value
		+	-	Total		
Preoperative	1-week abstinence	5	88	93	2.642	.074
	Non-smoker	12	558	570	(0.909-7.681)	
	4-week abstinence	6	144	150	1.938	.194
	Non-smoker	12	558	570	(0.715-5.251)	
	1-year abstinence	1	11	12	4.227	.184
	Non-smoker	12	588	570	(0.505-35.413)	
	4-week abstinence	6	144	150	0.733	.617
	1-week abstinence smoker	5	88	93	(0.217-2.474)	
	1-year abstinence	1	11	12	2.182	.488
	4-week abstinence smoker	6	144	150	(0.241-19.771)	
	24-hour abstinence	1	37	38	1.257	.828
	Non-smoker	12	558	570	(0.159-9.930)	
Post-operative	1-week abstinence	5	88	93	2.642	.074
	Non-smoker	12	558	570	(0.909-7.681)	
	1-week abstinence	5	88	93	2.102	.504
	24-hour abstinence	1	37	38	(0.237-18.619)	

Abbreviations: CI, confidence interval; OR, odds ratio.

Hematoma according to the post-operative abstinence period. The hematoma rate did not differ significantly in non-smokers and smokers who were abstinent for 24 hours post-operatively (n = 608, OR = 1.257, 95% CI = 0.159-9.930, $P = .828$; Table 4). No significant difference was found between non-smokers and smokers who were abstinent for 1 week post-operatively (n = 663, OR = 2.642, 95% CI = 0.909-7.681, $P = .074$). Likewise, no significant difference was found between smokers who were abstinent for 24 hours or 1 week post-operatively (n = 131, OR = 2.102, 95% CI = 0.237-18.619, $P = .504$).

Table 5. Fat Necrosis in Patients With or Without Smoking History.

Author	Year	Area	Flap Name	With Smoking History			Without Smoking History			P
				Pt	Fn	%	Pt	Fn	%	
Chang et al ⁷	2000	Breast	TRAM	90	20	22.2	478	31	6.5	.003
Peeters et al ¹⁷	2009	Breast	DIEP	22	14	63.6	160	85	53.1	
Total				112	34	9.2	638	116	18.2	

Abbreviations: DIEP, deep inferior epigastric artery perforator; Fn, number of fat necrosis; Pt, total patients; TRAM, transverse rectus abdominis myocutaneous.

Fat Necrosis

Among 750 patients from 2 papers, 150 (20%) cases of fat necrosis were reported.^{7,17} Of these patients, 638 (from 2 papers)^{7,17} were non-smokers and 112 (from 2 papers)^{7,17} were smokers. Fat necrosis occurred significantly more frequently in smokers (30.4%, 34/112 patients) than in non-smokers (18.2%, 116/638 patients, $P = .003$ [independent 2-sample t test]; Table 5).

Discussion

All the studies analyzed were retrospective database studies because no randomized controlled studies were available on the topic of smoking and flap survival. The limitations of this study are the limited number of studies, since most of the papers we initially identified did not present details regarding the smoking amount (pack-years), smoking periods, or preoperative and post-operative abstinence periods. In this article, we were not able to consider other risk factors (eg, diabetes and hypertension) that may have influenced the occurrence of complications.

In our review, we found that post-operative complications such as flap necrosis ($P < .001$), hematoma ($P < .001$), and fat necrosis ($P = .003$) occurred significantly more frequently in smokers than in non-smokers.

The flap loss rate was significantly higher in smokers who were abstinent for 24 hours post-operatively than in non-smokers ($n = 1464$, OR = 4.885, CI = 2.071-11.524, $P < .001$). The flap loss rate was significantly lower in smokers who were abstinent for 1 week post-operatively than in those who were abstinent for 24 hours post-operatively ($n = 131$, OR = 0.252, CI = 0.074-0.851, $P = .027$). Thus, it is suggested that a post-operative abstinence period of at least 1 week is necessary for smokers who undergo a flap operation (Figure 2, upper).

No significant differences were found in flap loss between non-smokers and smokers who were abstinent for 1 week preoperatively ($n = 1519$, OR = 1.229, 95% CI = 0.482-3.134, $P = .666$) or 4 weeks preoperatively ($n = 1576$, OR = 1.902, 95% CI = 0.383-2.119, $P = .812$). Although a preoperative abstinence period of 4 weeks is recommended, we suggest that a preoperative abstinence period of at least 1 week is necessary for smokers who plan to undergo a flap operation.

The cardiovascular responses to nicotine are due to stimulation of the sympathetic ganglia and the adrenal medulla, together with the discharge of catecholamines from

Figure 2. Mechanism of smoking and abstinence periods. Upper: Preoperative and post-operative abstinence periods for smokers who undergo a flap operation. Lower: Mechanism of effect of smoking on flap loss. COPD indicates chronic obstructive pulmonary disease; Cx, complication; d, day; m, month; PaO₂, alveolar oxygen pressure; PsqO₂, subcutaneous wound tissue oxygen; w, week.

sympathetic nerve endings and chromaffin tissues of various organs.¹⁹ Nicotine also activates the sympathomimetic response in chemoreceptors of the aortic and carotid bodies, which results in vasoconstriction, tachycardia, and elevated blood pressure.²⁰ Any decrease in the alveolar oxygen pressure (PaO₂) due to smoking would lead to a decrease in subcutaneous wound tissue oxygen (PsqO₂) as well, but the effects of smoking on PaO₂ tend to be more chronic than acute. Smoking is a risk factor for chronic obstructive pulmonary disease (COPD). In COPD, decreased PaO₂ can lead to decreased baseline subcutaneous wound tissue oxygen (PsqO₂) in smokers. Vasoconstriction due to nicotine intake in patients with an already decreased PsqO₂ due to COPD can lead to flap loss (Figure 2, lower).²¹ Since smoking reduces PaO₂ and PsqO₂, and nicotine causes vasoconstriction, smokers are more likely to experience flap loss, hematoma, or fat necrosis than non-smokers. Preoperative and post-operative abstinence periods of at least 1 week are necessary for smokers who undergo flap operations.

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Supplemental Material

Supplemental material for this article is available online.

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