

## Smoking increases failure rate of operation for established non-union of the scaphoid bone

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**Abstract** The aim of the study was to investigate the effect of smoking on the operative treatment of established non-union of the carpal scaphoid. Case notes and radiographs of patients undergoing bone grafting and screw fixation of scaphoid non-unions were reviewed. There were 34 patients that had undergone 37 operations for established non-union of the carpal scaphoid bone. There were two female patients, and the average age was 26.8 years (range 13.4 years to 52.9 years). The median delay to operation was 11.9 months. The overall success rate of the operation (internal fixation and autologous bone grafting) was 59.5% (22/37), but there was a significant association between non-union and smoking ( $P=0.02$  for Fisher's exact test). In non-smokers ( $n=17$ ) the success rate was 82.4%, but this dropped to 40.0% among smokers ( $P<0.01$ ). We concluded that smoking was significantly associated with failure of operative treatment of established non-union of the scaphoid bone.

**Résumé** Le but de cette étude est d'évaluer les effets de la cigarette dans le traitement chirurgical des pseudarthroses du scaphoïde carpien. Méthode nous avons revu les dossiers cliniques et radiographiques des patients devant bénéficier d'une greffe et d'un vissage pour une pseudarthrose du scaphoïde. Résultats : 34 patients ont bénéficié de 37 opérations pour une pseudarthrose du scaphoïde carpien. Il s'agissait de deux sujets de sexe féminin, les autres patients étant de sexe masculin, la moyenne d'âge étant de

26,8 ans (13.4 à 52.9). Le délai moyen de réintervention a été de 11.9 mois. Le taux de bons résultats (fixation interne et greffe autologue) a été de 59.5% (22/37) mais il a été mis en évidence une relation significative entre le taux de pseudarthrose et le nombre de sujets fumeurs ( $p=0.02$  thèse de Fisher). Chez les sujets non fumeur,  $n=17$ , le taux de succès a été de 82.4%, alors qu'il n'est que de 40% chez les fumeurs. En conclusion, la cigarette peut être associée avec un taux d'échec du traitement chirurgical des pseudarthroses du scaphoïde.

### Introduction

The fractured scaphoid has a non-union rate that has been variously reported as being between 5% and 12% [4, 7, 10], although some authors put it as high as 47% [5]. Such wide variation is due to different radiographic criteria of non-union as well as the fact that some fracture patterns have a worse prognosis than others. Established non-union often causes wrist pain and weakness of grip and may predispose individuals to degenerative changes in the wrist. Internal screw fixation, usually with supplementary autologous bone graft, is a recognised form of treatment to achieve bony union and reduce progression of degenerative changes [5]. There have been several studies documenting good results of screw fixation with autologous bone graft: post-operative radiographic union rates of about 80% to 90% have been achieved in the larger studies ( $n>50$ ) [2, 5, 8]. Various factors that reduce the success rate of surgery have been identified, such as proximal fracture, delay to surgery, avascular necrosis and osteoarthritis [5, 8, 11]. The effect of patient factors is less well defined, and this study looks specifically at the effect of smoking on the outcome of surgery for the un-united scaphoid fracture.

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## Patients and methods

A manual trawl through dedicated operating lists identified all patients that had undergone surgery for scaphoid non-union under the care of R.H.V. between 1992 and 2003. The case notes were retrieved, and the relevant data were extracted. Smoking status was specifically recorded as part of the anaesthesia assessment. The diagnosis of persistent post-operative non-union was based on radiographic evidence of a visible fracture line or non-incorporation of the bone graft. Patients with incomplete case notes or radiographs were excluded from the analysis.

Parametric data were described using means and ranges and were compared with Student's (two-tailed) *t*-test. Non-parametric data were described using medians and ranges, and the significance of observed differences were determined with the Mann–Whitney test. Chi-squared and Fisher's exact test were used for categorical data, and proportions were compared using Student's *t*-test. A *P* value of less than 0.05 was taken as significant.

## Results

There were 37 operations performed on 34 patients, with two patients having repeat procedures (after failure of initial surgery) and one patient having bilateral operations. Most injuries were sustained during sporting activities or domestic falls. No patient had any other ipsilateral concurrent wrist or hand fractures or dislocations. There were only two female patients in the group, details of which are given in Table 1.

R.H.V. performed or directly supervised all the operations. All the procedures involved internal screw fixation with bone grafting, except four: two had bone grafting alone, and a further two had screw fixation alone. Among the 35 operations using screw fixation, a cannulated AO screw was used in 25 cases, and a Herbert screw was used in the remaining ten cases. All operations were performed under general anaesthesia and tourniquet control. All patients were placed in a below-elbow cast post-operatively.

Smoker and non-smoker sub-groups were comparable in terms of fracture location, delay to operation, implant used and duration of post-operative immobilisation (Table 2). The overall success rate of the operation was 59.5% (22/37), but there was a significant difference between the success rates of smokers and non-smokers [40.0% (8/20) vs 82.4% (14/17); *P* < 0.01]. There was a significant association between smoking and persistent non-union (Fisher's exact test, *P* = 0.02). The relative rate of smokers having a persistent non-union was 3.4 (0.60/0.176) compared to smokers.

**Table 1** Patients undergoing bone graft and screw fixation for scaphoid non-union

Parameter		All patients
Number		37
Age (years)	Mean	26.8
	Range	13.4–52.9
Fracture location	Distal	3
	Waist	25
	Proximal	9
Screw type	AO	25
	Herbert	10
Time between injury and operation (months)	Median	11.9
	Range	2.5–85.8
Post-operative time in plaster cast (weeks)	Mean	7.2
	Range	2.0–17.4
Final outcome	United	22
	Not united	15
	Union rate	59.5%

## Discussion

The effect of smoking on bony healing has been investigated mainly in long-bone fractures. Smoking impairs bony healing in acute tibial fractures, whether treated operatively [1, 13] or non-operatively [9]. However, in established non-union of femoral fractures, one study found that the operative intervention was sufficient to overcome the effect of smoking on bone healing [6]. Another study looked at the effect of pulsed ultrasound therapy on a heterogeneous group of 29 un-united fractures of the upper and lower limb that included five cases of scaphoid non-union [12]. Smoking was associated with persisting non-union, despite the ultrasound therapy.

As for operative treatment of established scaphoid non-union, factors causing persistent non-union include delay of over 5 years to surgery, presence of avascular necrosis, and proximal fracture location [5, 8, 11]. The effect of smoking, however, has not previously been specifically investigated.

This study found a significant association between failure of operative treatment of established scaphoid non-union and a history of smoking (Fisher's exact test *P* = 0.02). Bone grafting and internal screw fixation had a lower success rate in smokers than in non-smokers (40.0% vs 82.4%; *P* < 0.01). Conversely, the non-union rate was 3.4-times higher among smokers (60.0% vs 17.6%, *P* < 0.01).

However, this study has several limitations. Firstly, it is quite a small study, with only 37 cases. Also, its retrospective nature does not allow for confounding factors. Nevertheless, as shown in Table 2, factors such as delay to surgery, age at operation, fracture location and duration of post-operative immobilisation were similar among smokers and non-smokers. Another concern may be that two types of fixation were used, namely AO

**Table 2** Comparison of smokers and non-smokers undergoing bone graft and screw fixation for scaphoid non-union

Parameter		Smokers	Non-smokers	Difference <sup>a</sup>
Number		20	17	
Age (years)	Mean	26.4	27.1	$P=0.8$
	Range	17.0–37.9	13.4–52.9	
Fracture location	Distal	2	1	$P=0.2$
	Waist	14	11	
	Proximal	4	5	
Screw type	AO	12	13	$P=0.2$
	Herbert	7	3	
	None	2	0	
Time between injury and operation (months)	Median	11.2	13.1	$P=0.6$
	Range	2.6–85.8	2.5–65.6	
Post-operative time in plaster cast (weeks)	Mean	7.0	7.4	$P=0.7$
	Range	2.0–16.9	5.3–17.4	
Final outcome	United	8	14	$P=0.02$
	Not united	12	3	
	Union rate	40.0%	82.4%	$P<0.01$

<sup>a</sup> Student's *t*-test for parametric data and Mann–Whitney test for non-parametric data; chi-squared or Fisher's exact test for categorical data

cannulated screws and Herbert screws. However, previous studies have shown these two implants to have similar union rates in scaphoid bone grafting and fixation for non-union [2, 14]. Furthermore, the various types of fixation did not differ significantly between smokers and non-smokers ( $P=0.02$ ).

The retrospective nature of this study precludes the determination of the relative risk (RR) of smokers having a persisting non-union. Although the odds ratio (OR) of smokers having persisting non-union can be calculated from the data, the OR only approximates the RR when the background rate of the event is low [3]. In this case the failure rate of the operation is at least 10% [8], which is relatively high. The OR of 7.0 (95% CI 1.5 to 32.5) is thus an over-estimate of the RR of smoking causing persistent non-union, and the true RR may actually be approximately 3 [3]. Larger prospective studies are required to determine accurately the RR of failure of bone grafting and internal screw fixation for established scaphoid non-union among smokers compared with non-smokers.

## Conclusion

This study found a significant association between smoking and failure of operative treatment of scaphoid non-union. The persistent non-union rate was over three-times higher in smokers than non-smokers.

**Conflict of interest** The authors declare that they have no conflict of interest.

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