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Impact of Smoking on Clinical Outcomes of Open Arthrolysis for Post-Traumatic Elbow Stiffness

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Abstract

Background: Elbow stiffness is a common orthopedics problem after elbow trauma. Meanwhile, smoking is becoming a worldwide public health challenge, which has been considered as a predisposing factor for adverse functional outcomes after various orthopedic surgeries. This retrospective study seeks to identify whether smoking affects clinical outcomes of open arthrolysis for post-traumatic elbow stiffness in male patients.

Methods: A total of 95 male patients referred to our institution received open arthrolysis for post-traumatic elbow stiffness from January 2015 to August 2016 were divided into 2 groups: currently smoking group (n=36) and currently non-smoking group (n=59). General patients' data and elbow functions like range of motion (ROM), forearm rotational arc, Mayo Elbow Performance Sore (MEPS), Visual Analogue Score (VAS), ulnar nerve symptoms and muscle strength were documented.

Results: Significant differences were found in ROM (P=0.017), MEPS (P=0.004) and VAS (P=0.035) between the 2 groups, and currently smoking group had the poorer clinical outcomes. However, no differences were found in forearm rotational arc (P=0.057) and complications such as ulnar nerve symptoms (P=0.431), reduced muscle strength (P=0.948) and elbow instability (P=0.369).

Conclusions: Patients who smoke are at increased risk of poorer outcomes after open artholysis for post-traumatic elbow stiffness. Therefore, attention and interference may be instructed to patients who smoke after open arthrolysis in daily clinical work, such as smoking cessation.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Post-traumatic elbow stiffness; Open arthrolysis; Smoking; Clinical outcomes

Background

100° arc of the elbow for both flexion-extension (30° to 130°) and pronation–supination (50° in either direction) is functional enough for daily activities, according to Dr. Morrey [1]. Attributing to increasing development of industrialization and transportation, however, elbow stiffness is a common complaint after elbow trauma, with an incidence ranging from 3% to 20% [2]. Generally, arthrolysis is indicated when patients have no (further) prospect of effect by conservative therapy [3].

Arthroscopic techniques are considered preferentially only for simple elbow contractures from Jupital's classification in most conditions [4]. Open arthrolysis is still the commonest treatment method, which has been proven to be an effective choice with low incidence of complications [3,5].

Nowadays, hazards from smoking are one of the most serious public health problems in the world, which is closely related to tumors [6], cardiovascular disease [7], cerebrovascular diseases [8], respiratory diseases [9], and so on. 100 million people died from smoking in the 20th century, according to WHO in 2008, and one billion people in the 21st century are expected to die from tobacco use [10]. Based on an epidemiological investigation in 2010, the prevalence of smoking adult males in China was 53.3%, and the intention of smoking cessation was declined with age [11].

Attributing to affect the conditions of local tissues by tissue-induced hypoxia, decreased oxygen-carrying capacity, vasoconstriction and decreased collagen production [12], great attentions have showed smoking as a major risk factor for adverse clinical outcomes and development of postoperative complications in multiple orthopedic surgeries, including increased risk of post-operative infection [13], chronic wound healing [14], decrease in the tensile strength [15], reduced muscle strength [16], nerve symptoms [17], increased mortality risk [18], and so on .

This retrospective study seeks to identify whether smoking affects clinical outcomes of open arthrolysis for post-traumatic elbow stiffness in a cohort of male patients who were referred to our institution. Given the evidence that smoking is a predisposing factor for increased complications and adverse functional outcomes after different orthopedic procedures, we hypothesized that smoking would have a similar negative effect on outcomes after elbow arthrolysis in male patients.

Materials and Methods

Patients

This study was a retrospective case series of patients who presented to our institution with elbow stiffness between January 2015 and August 2016. Inclusion criteria concluded (1) male patients, (2) skeletally mature, (3) stiff elbow with a total arc of flexion and extension <100°, (4) caused by trauma, (5) treated with open arthrolysis. Exclusion criteria were (1) follow-up time less than 12 months, (2) age less than 18 years old, (3) prior elbow release, (4) associated with severe burn or central nervous system injuries. 198 patients underwent surgery for elbow stiffness at our institution and 103 met the inclusion and exclusion criteria during the referent period for this study. Due to refuse or loss-to follow up, however, 8 of the 103 patients were excluded. The remaining 95 patients were divided into 2 groups: currently smoking group (n=36) and currently non-smoking group (n=59). General patients' demographics, including age (years), body Mass Index (BMI) (Kg/m2), dominant limb (No.), original injury type (No.), fracture site (No.), treatment method (No.), rehabilitation program (No.), dysfunction time (months), immobilization time (weeks) and follow-up time (months) were documented. Preoperative characteristics like extension (°), flexion (°), range of motion (ROM) (°), pronation (°), supination (°), forearm rotational arc (°), Mayo Elbow Performance Sore (MEPS) (points), Visual Analogue Score (VAS) (points), ulnar nerve symptoms (No.), muscle strength (No.) and elbow stability (No.) were also recorded. Among these data, original injury type was subdivided into dislocation, proximal ulnar, distal humerus, radial head and multiple fractures. A goniometer was used to assess motion of the injured elbow and Dellon classification was applied to evaluate ulnar nerve symptom [19]. Elbow stability was tested through stress test and pivot shift test [20]. At the last follow-up, postoperative characteristics were collected the same as preoperative. (Tables 1 and Table 2 show the demographics and preoperative clinical evaluation of the included 95 patients)

Surgical technique

All patients were performed in the supine position under general anesthesia by the same surgeon (C.-Y.F.). A sterile tourniquet was applied. Surgical exposure either through a combined lateral and medial incision or a posterior midline incision was determined by whether there was an incision made in the previous surgery. As for medial approach, the ulnar nerve was identified and released. Then split and reflected the margins of the triceps tendon off the distal humerus to expose the posterior part of the elbow. Subsequently, the posterior and transverse bundle of the medial collateral ligament and posterior capsule were released, and bony impediments or scar tissues present within the olecranon fossa were removed under direct visualization, and plasty of the olecranon was performed. The extended Kocher approach was used for the lateral incision. Partial incision of lateral collateral ligament, excision of hypertrophic anterior capsule, clearance of radial and coronoid fossa under direct visualization, and plasty of the coronoid were routinely performed. The same surgical procedure was performed for patients with a posterior midline incision. Sufficient release was indicated when passive mobility of 0° to 130° was achieved. Elbow stability was tested through stress test and pivot shift test [20] to determine the method of collateral ligament repair, that was, anchor [21] or direct suture. Then, a hinged external fixator (Orthofix, Verona, Italy) [22] was applied to the elbow along the elbow rotational axis and identified by C-arm radiography to provide additional stability and enable early elbow joint mobilization in a controlled manner. Anterior transposition subcutaneously and stabilization of the ulnar nerve by use of fascial slings were performed. Two drainage tubes were left to prevent hematoma and the wound was closed in layers after local application of vancomycin powder [23].

Postoperative treatment

Indomethacin (25 mg, 3 times a day) was prescribed postoperatively for approximately 4 to 6 weeks to prevent heterotopic ossification. Early rehabilitation was instructed according to the achieved ROM documented in operation. Starting from the first postoperative day, patients were instructed to perform cycle exercises of flexion and extension, in other words, active-(active-assisted)-passive elbow motion. This progressive exercise program was continued for as long as 6 months after the surgery. Hinged external fixator was removed 6 weeks postoperatively as an outpatient procedure.

Statistical analysis

Continuous data are presented as the mean when they are normally distributed; otherwise, the median and interquartile range are reported. We compared independent variables at a time between current smoking and non-smoking patients by bivariate analysis to examine associations, such as Independent Samples T test for ROM, Fisher's exact test or Pearson chi-square for categorical data like ulnar nerve symptoms. Associated P values<0.05 were considered indicative of a statistically significant between-group difference. Statistical analysis was performed with IBM SPSS 22.0 software (IBM Corp., Armonk, NY, USA). (*P<0.05; ** P<0.01; ***P<0.001)

Results

All kinds of data preoperatively showed no difference between the 2 groups (current smoking and non-smoking group) (showed in Tables 1 and 2). At the last follow-up, data indicated significant difference in extension (P=0.034), flexion (P=0.019), ROM (P=0.017), MEPS (P=0.004) and VAS (P=0.035). To be specific, we found that ROM in the non-smoking group (119 ± 14) was higher than smoking group (109 ± 21), as well as MEPS between non-smoking group (93 ± 9) and smoking group (87 ± 11). In addition, the VAS scores were significantly higher in smoking group (1.5 ± 1.5) than in non-smoking group (0.9 ± 1.2) postoperatively. What's more, no differences were discovered in pronation (P=0.05), supination (P=0.123) and forearm rotation arc (P=0.057) (Table 2 shows postoperative clinical evaluation of patients between the 2 groups at the final follow-up).

Variables		Smoking	Non-Smoking	P value
Dorminant Limb	Yes	23	38	0.959

	No	13	21	
Treatment Method	Operative	33	49	0.38
	Conservative	3	10	
Rehabilitation	Yes	14	23	0.993
	No	22	36	
Fracture Site	Dislocation	3	4	0.242
	Proximal ulnar	10	10	
	Distal Humerus	7	25	
	radial head	3	4	
	Multiple Fractures	13	16	
Age (years)		35 ± 10	34 ± 11	0.655
Body Mass Index (kg/m2)		24.2 ± 3.1	23.3 ± 3.4	0.217
Dysfunction Time (months)		30 ± 47	27 ± 50	.0768
Immobilization Time (weeks)		2.5 ± 2.8	2.7 ± 2.9	0.801
Follow-up Time (months)		23 ± 8	23 ± 8	0.907

Table 1: Demographics and clinical characteristics of patients.

Overall, 3 different new on-set or deteriorative complications were observed at the final follow-up, including ulnar nerve symptoms, reduced muscle strength and instability. No other complications like infection were reported. 4 patients in the non-smoking group presented with new onset or exacerbation of ulnar nerve symptoms, meanwhile 5 patients in smoking group were discovered. In the non-smoking group, 5 and 4 patients had new onset or exacerbation of reduced muscle strength and instability problems respectively, while 4 and 1 patients in smoking had the same problems. At last, no differences were found in ulnar nerve symptoms (P=0.431), reduced muscle strength (P=0.948) and instability (P=0.369) (Table 3 shows difference of complications between the 2 groups).

Variables	Smoking	Non-smoking	P value
Preoperative data, Mean±SD			
Extension	42 ± 18	38 ± 18	0.269
Flexion	76 ± 23	78 ± 23	0.636
ROM	34 ± 25	41 ± 24	0.216
Pronation	38 ± 34	49 ± 29	0.082
Supination	59 ± 33	66 ± 33	0.344
ARC	97 ± 55	115 ± 57	0.129
MEPS	69 ± 11	69 ± 13	0.879
VAS	1.4 ± 1.7	1.3 ± 1.7	0.744
Postoperative data, Mean±SD			
Extension	13 ± 15	8 ± 8	0.034*
Flexion	122 ± 11	127 ± 8	0.019*
ROM	109 ± 21	119 ± 14	0.017*
Pronation	59 ± 28	69 ± 15	0.05
Supination	74 ± 26	81 ± 18	0.123
ARC	133 ± 47	150 ± 33	0.057
MEPS	87 ± 11	93 ± 9	0.004**
VAS	1.5 ± 1.5	0.9 ± 1.2	0.035*

Table 2: Patients' clinical evaluation.

Variables		Smoking	Non-Smoking	P value
Nerve symptom	Yes	5	4	0.431
	No	31	55	
Reduced Muscle strength	Yes	4	5	0.948
	No	32	54	
Elbow Instability	Yes	1	4	0.369
	No	35	55	

Table 3: New onset or exacerbation of postoperative complications.

Discussion

Nowadays, the global prevalence and incidence of smoking is steadily arising in all populations, especially in men, which is becoming a worldwide public health challenge. Recently, great attentions have been paid to the relationship between smoking and orthopedic surgery outcomes, such as total joint arthroplasty [24], osteoarthritis [25], fractures [26], ligament reconstruction [27], and most of them showed negative effects of smoking on postoperative outcomes.

To our knowledge, no study available up to now has discussed smoking as a negative factor on clinical outcomes of open arthrolysis for patients with post-traumatic elbow stiffness, especially in male patients. This study adds a new joint to the growing body of literature concerning the association of smoking and clinical outcomes after open arthrolysis in male patients with post-traumatic elbow stiffness, basing on ROM, MEPS, VAS and complications.

Multiple basic researches have showed that smoking is closely related with fibrosis through ERK/MAPK and TGF-Beta/Smad signaling pathways, which play important roles in fibroblast proliferation and collagen expression, leading to capsule fibrosis and tendon adhesion [28,29]. At the final follow-up, the overall trend in our study showed that elbow arthrolysis offers significant improvements in the elbow ROM in both 2 groups, however, we demonstrated that elbow ROM of non-smoking patients was superior to that of smoking patients after elbow arthrolysis in this study. In addition, 9 patients (25.0%) in non-smoking group still had a ROM ≤ 100°, which were significant higher ($P=0.012$) than that in non-smoking group (5.1%). As for forearm rotational function, however, we didn't discover any difference between the 2 groups. What's more, we found non-smoking patients not only had a significantly higher MEPS scores but also had a significant higher ($P=0.028$) satisfactory proportion (98.3%) than smoking patients (86.1%). Thus, smoking patients should be counseled preoperatively that their postoperative expectations should be tempered.

Several studies have showed the intimate relationship between smoking and pain. Nicotine interaction with nicotinic acetylcholine receptors (nAChRs) can produce analgesic effects, however, nAChRs structure and function change in the long-term smokers, resulting in nAChRs desensitization and the increase in the number of receptors, which may lead to pain hypersensitivity [30]. Epidemiological survey found that smoking was a high risk factor for chronic low back pain [31]. And smoking was reported to be associated with increased postoperative pain, VAS scores, intraoperative and postoperative opioid consumption [32,33]. In our study, similarly, patients in smoking groups obtained significant higher VAS scores compared with non-smoking patients at the last follow-up, which was consistent with previous studies.

As a microvascular change, previous work suggested individuals who smoke were at increased risk of developing ulnar neuropathy at the elbow [34,35]. According to Richardson JK, smoking is associated with increased risk for ulnar neuropathy at the elbow in a dose-response effect [36]. In our study, 9 patients (9.5%) developed new onset or exacerbation of ulnar nerve symptoms after elbow arthrolysis, 4 in non-smoking group and 5 in smoking group, however, no difference was found in nerve complication rates between the 2 group. The relationship between cigarette smoking and muscle strength has been studied previously. Research showed that tobacco smoke inhalation affects muscle flexibility and strength in healthy adults or athletes, as well as grip strength [37-39]. In our study, total 9 (5 in non-smoking group and 4 in smoking group) patients developed reduced muscle strength at the final follow-up, however, there were no difference between both groups. As for postoperative instability, 5 (4 in non-smoking group and 1 in smoking group) patients were included, and no difference was found either.

Several inherent limitations were included in this study besides the retrospective nature. The sample size was relatively small and the numbers of postoperative complications were too small to make meaningful statistical comparisons between the 2 groups. What's more, due to the relatively small number of female smokers in China, this study only observed the impact of smoking in male patients, so that it may not be applicable to the whole population. In addition, it would be better if this study contained another group, that was, smoking cessation group.

Conclusion

This study adds a new joint to the growing body of literature supporting the idea that patients with post-traumatic elbow stiffness who smoke are at increased risk of poorer performance after elbow open artholysis. Although most patients showed significant improvements after operation, the postoperative functional outcomes of smoking patients were inferior to those of non-smoking to a certain extent. For daily clinical work, our results may help operators to pay attention to the smoking patients after open arthrolysis, such as smoking cessation. In addition, further prospective studies including a larger sample size, longer follow-up duration, another smoking cessation group and even female patients are needed to validate the results of this study further.

Compliance with Ethical Standards

Disclaimer

The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Competing interests

The authors declare no competing financial interests.

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Ethical approval

The Ethics Committee of Shanghai Jiao Tong University Affiliated Sixth People's Hospital concluded that no approval is necessary for study based on its retrospective design. Data were analyzed anonymously; all patients approved the results of this study by oral consent. The oral consent approval was documented in the patients' files. This was approved by the Ethics Committee of Shanghai Jiao Tong University Affiliated Sixth People's Hospital. All clinical investigations were conducted in accordance with the guidelines of the Declaration of Helsinki.

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