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Hand surgeons performing more open carpal tunnel releases do not show better patient outcomes

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Abstract

Background—While previous studies have shown that more experienced surgeons have better patient outcomes following a variety of procedures, in hand surgery and carpal tunnel release (CTR) in particular, this relation remains unknown. The aim was to assess whether there is an association between surgeon volume and patient outcomes following open CTR.

Methods—Patients who underwent CTR between 2011 and 2015 at outpatient hand surgery clinics in the Netherlands were included. Surgeon annual volume was defined as the average number of CTRs performed per year per participating surgeon over the study period. Primary outcome measures were the symptom severity score (SSS) and functional status score (FSS) of the Boston Carpal Tunnel Questionnaire (BCTQ) 6 months postoperatively. Multilevel random intercept linear regression analyses were performed to assess whether there was an association between surgeon annual volume and outcome measures, with adjustment for patient characteristics, concomitant procedures and intake score on BCTQ.

Results—A total of 1345 patients were included, operated on by seventeen surgeons. Median (IQR) annual surgeon volume was 75 (50 – 149). Only 0.5%-0.6% of the total variance in patient outcome on BCTQ could be explained by random differences between surgeons. We did not find an association between annual surgeon volume and outcome measures 6 months postoperatively (SSS: $\beta=.000$, 95% confidence interval [CI] $-.001 - .001$, FSS: $\beta=.000$, 95% CI $-.001 - .001$).

Conclusions—In our sample of highly specialized hand surgeons operating in high volume centers, we found no differences in outcome between high and low volume surgeons.

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Keywords

annual surgeon volume; carpal tunnel release; hand surgery

Introduction

Previous studies have shown that more experienced surgeons have better patient outcomes following a variety of surgical procedures, including gastro-intestinal, cardiac, lung and vascular operations¹⁻⁴. In addition, such relationships have also been found in surgery of the musculoskeletal system⁵⁻⁷. Since it can be challenging to quantify a surgeon's cumulative surgical experience for a specific procedure and cumulative experience can be deceptive, annual operative volume is often used to assess the relationship between surgeon volume and patient outcome¹⁻⁴.

Carpal tunnel release (CTR) is one of the most common surgical procedures and the most frequent surgery of the hand and wrist, with estimates of 400.000 to 600.000 carpal tunnel releases performed annually in the United States^{8,9}. Nevertheless, in hand surgery in general, and in carpal tunnel release in particular, it remains unknown whether there are outcome benefits to repetition for individual surgeons.

There are various reasons why experience might be beneficial in the context of CTR. For example, a higher volume surgeon might be better prepared to handle anatomical variations, extensive fibrosis, or other challenging situations. Additionally, incomplete transection of the transverse carpal ligament is a relatively common reason for unrelieved symptoms following CTR^{10,11}, which might be less likely to occur in more experienced surgeons.

Conversely, despite the specific challenges of CTR, it has been suggested that trained nurse practitioners might be able to perform CTR, with the same results on patient outcome as achieved by surgeons^{12,13}. A reported argument for having a nurse practitioner operate is reduction in waiting time for CTR^{12,13}. This suggests that operator's education is not considered a predictor for outcome after CTR. A recent study assessed the effects of hand fellowship training on rates of complications for both endoscopic and open carpal tunnel release¹⁴. Neither operative technique nor type of fellowship training (hand fellowship training versus non-hand fellowship training) had a statistically significant impact on overall complication rates, suggesting that for carpal tunnel release specifically there is no association between surgeon training and complication rate. However, these results were neither adjusted for potential confounding factors nor for baseline measurements. Fellows were possibly less likely to treat complicated cases, for example patients with comorbidities or more severe symptoms, compared to more senior hand surgeons. Furthermore, it has not been assessed whether, within the surgeon population, there is an association between surgeon experience and patient outcome.

Therefore, the aim of this study was to assess whether there is an association between annual surgeon volume and patient outcomes at six months postoperative following open CTR.

Methods

Data collection

All patients with CTS who underwent carpal tunnel release between 2011 and 2015 at one of the eleven specialized outpatient hand surgery clinics (Xpert Clinic) in the Netherlands were eligible for the study. As part of routine clinical care, patients were included in a large multicenter web-based database, which contains patient-rated outcome measures. All patients signed informed consent and the study was approved by our local ethics committee. Patients who underwent a primary CTR and had at least a baseline measurement and one follow-up measurement on the Boston Carpal Tunnel Questionnaire (BCTQ) were included in the study. Patients where an operative report was not available or surgeon could not be identified were excluded. In addition, patients operated by a surgeon who performed CTRs for less than one year in our cohort were also excluded.

Covariates of interest

The following study data were abstracted from the database, since they are known prognostic factors for clinical outcome following CTR identified based on literature review^{15–20}: age, sex, smoking status, alcohol use, comorbidities: rheumatoid arthritis, diabetes mellitus, peripheral neuropathy, cervical radiculopathy, trigger fingers, tendinitis, radiocarpal arthritis, carpometacarpal (CMC) arthritis, scaphotrapezotrapezoidal (STT) arthritis, history of trauma of the wrist, Dupuytren's disease, cubital tunnel syndrome, ulnocarpal impingement, radial tunnel syndrome and Wartenberg's syndrome. For the analysis, cubital tunnel syndrome, radial tunnel syndrome, Wartenberg's syndrome and pronator syndrome were grouped under 'other nerve compressions'. In addition, a group 'other comorbidities' was defined, including the following comorbidities: STT arthritis, radiocarpal arthritis, peripheral neuropathy, cervical radiculopathy and ulnocarpal impingement. Concomitant procedures, i.e. procedures carried out at the same time as the carpal tunnel releases, were scored as well.

Outcome measures

Our primary outcome measure was the BCTQ score at 6 months postoperatively. The scores at intake were also abstracted, to be able to adjust for score at intake. In addition, to illustrate the course of the outcomes on BCTQ, measurements at 6 weeks and 3 months postoperatively were collected as well. Two domains of the BCTQ were assessed: the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS). The SSS and FSS consists of 11 and 8 items respectively. All items of both scales have 5 response categories ranging from 1 to 5 and higher score represents worse symptoms/lower level of function. Responses to items were averaged to create an overall score for each domain²¹.

The secondary outcome measure was overall pain assessed using the Visual Analog Scale (VAS), ranging from 0 to 100, 6 months postoperatively. Higher score represents greater pain intensity. The VAS was performed at intake and 6 weeks, 3 months and 6 months postoperatively.

In addition, adverse events were scored, including infections treated with antibiotics, wound dehiscence, postoperative bleeding and neuroma of the median nerve. We only scored adverse effects directly related to the carpal tunnel release. Information on the presence of adverse events was abstracted from the medical charts (SE, MJ).

Main exposure variable: annual surgeon volume

Surgeon volume was defined as all CTRs, including redo-procedures and concomitant interventions, performed by the participating surgeon, divided by the number of years the surgeon performed CTRs during the study period. Similar definitions of annual surgeon volume have previously been described^{1,7,22}. All procedures were performed by European Board Certified Hand Surgeons or surgeons following a hand fellowship.

Procedure

All patients underwent an open carpal tunnel release. Neither endoscopic procedures nor modifications were performed. In general, the following protocol was used in all treatment centers within the Xpert Clinic group, with only minor variations between surgeons:

Longitudinal incision was placed through the subcutaneous fat and palmar fascia until Guyon's canal. Fibers were revealed in the radial-ward direction and the transverse carpal ligament was divided. The median nerve was separated from the roof of the carpal tunnel in the proximal direction using scissors, where potential transverse fibers could be dissected. Subsequently, the tendons and median nerve were inspected. When hemostasis was obtained, the fat was repositioned and the skin sutured with Prolene 4/0. Sterile dressing and compression bandage was applied. All patients received standard postoperative care and hand therapy by a hand therapist consisting of nerve and tendon gliding exercises.

Statistical analysis

Parametric data were presented as mean and standard deviation (SD) and nonparametric data as median and interquartile range (IQR). We categorized the variable 'annual surgeon volume' for presentation purposes, using tertile-derived categories, into three subgroups: low volume, medium volume and high volume surgeons. Given the number of missing values, a non-responder analysis at six months postoperatively for baseline variables was performed using Chi-square statistics and unpaired T-tests. Based on this analysis we concluded that missing data could be classified as 'Missing Completely At Random'. Therefore, we used Multiple Imputation (MI) to impute the missing values²³. Ten versions of the dataset were produced and independently analyzed, each with its own set of imputed values. To give a single mean estimate, the pooled estimates of ten imputed datasets were used as statistical results.

Because of the hierarchical structure of the data (level 1=patients, level 2=surgeons) multilevel random intercept linear regression analyses were performed to assess whether there was an association between surgeon annual volume and outcome measurements. First, we ran an intercept only model to assess whether there was a significant difference in patient outcome across surgeons, regardless of surgeon volume. In addition, we calculated the intraclass correlation coefficient (ICC) to assess the overall variability in patient outcomes

between surgeons. An ICC close to zero would suggest no substantial variability between surgeons in patient outcomes. To adjust the estimated effect of surgeon volume for known prognostic factors identified based on literature review, the variables age, sex, smoking status, alcohol use, comorbidities, concomitant procedures and intake score for the respective questionnaire were included in the model as fixed factors.

P-values of <0.05 were considered statistically significant. Analyses were performed using Statistical Package for the Social Sciences (SPSS) version 21 (SPSS Inc., Chicago, IL, USA).

Results

A total of 2057 patients who underwent CTR within the specified time window were identified. After exclusions, 1345 patients were eligible for this study (Figure 1), operated on by seventeen surgeons: 16 hand surgeons and one surgeon in hand fellowship training. The annual surgeon volume ranged from 6 to 163 procedures per year, with median (IQR) volume of 75 (50 – 149) (Figure 2). Some of the variables had missing values due to non-response. Regarding the baseline variables, there were missing values for smoking status (35% missing) and alcohol use (35% missing). The proportion of missing data for all other baseline variables ranged from 0–1%. Regarding the outcome measures, there was a non-response of 0%, 52%, 13% and 27% for both the SSS and FSS score at baseline, 6 weeks, 3 months and 6 months postoperatively, respectively. These were 3%, 9%, 15% and 28% for the VAS score. Since adverse events were reported only in 1.6% ($N=23$) of cases, we did not use this variable as an outcome measure. Adverse events included wound infection in 18 cases and wound dehiscence in 5 cases. There were a total of 212 concomitant procedures. Table 1 shows the demographic, clinical and procedural characteristics of the cohort.

Figures 3 and 4 illustrate the course of the outcome measures, from intake to 6 months postoperatively, grouped by whether the surgeon was a low, medium or high volume surgeon for this procedure. The boundaries for the low, medium and high volume group were 6 – 44, 47 – 71 and 75 – 163 surgeries annually and there were 171, 459 and 715 patients in the low, median and high volume group, respectively. The low, median and high volume group included six, six and five surgeons respectively.

The ICC's ($p=0.005$ for the SSS, $p=0.006$ for the FSS and $p=0.002$ for the VAS) indicated that respectively only 0.5%, 0.6% and 0.2% of the patient outcome variance on the SSS, FSS and VAS 6 months postoperatively could be explained by random differences between surgeons. Unadjusted and adjusted models for the association between annual surgeon volume and patient outcome on the BCTQ (SSS and FSS domains) and VAS overall pain indicated no significant association between annual surgeon volume and patient outcome 6 months postoperatively for any of the outcome measures (Table 2). To assess whether the patient outcomes of the surgeon following a fellowship did influence the overall results, we also ran the analysis on the dataset including board certified hand surgeons only. The results remained unchanged.

Discussion

This study, based on a large cohort and including highly specialized surgeons only, did not show an association between annual surgeon volume and patient outcome after an open CTR assessed using BCTQ and VAS. In addition, we found that only 0.6% of the variance on the BCTQ 6 months postoperatively could be explained by random differences between surgeons, regardless of surgeon volume.

Previous studies have shown an association between surgeon volume and patient outcome, suggesting that centralization of some types of surgery in a small number of centers is beneficial^{2,22}. In hand surgery specifically, it is unknown whether there is an association between surgeon volume and patient outcome. It could be argued that surgeon experience might mainly be beneficial in technical challenging procedures, but data are lacking for both more challenging more complex procedures as well as for more simple procedures in hand surgery.

The overall improvement in functional status and symptom severity found in our study is in line with literature²⁴. Katz et al. described patient outcomes after an open CTR carried out by 26 surgeons in different offices in Maine²⁴ with symptom severity and functional status 6 months postoperatively similar to our results despite that symptom severity and functional status at intake was slightly higher at baseline compared to our cohort. Mack et al. reported patient outcomes at 3 months following open CTR on 134 patients²⁵ and found a slightly larger change from baseline compared to our results. Total reported adverse events were slightly higher than our results, with wound dehiscence in 4% and infection in less than 1% of cases compared to 0.4% and 1.3% respectively in our study. Smetana et al. reported a similar incidence of wound dehiscence of 1.2% and median nerve palsy or injury in 0.22% of 28,086 cases of isolated open CTR while infection rate was not reported¹⁴.

The main strength of our study is the size of the study population and the detailed outcome assessment, compared to many studies only focusing on symptom or pain reduction²⁶. We were able to test our hypothesis on a relatively large database due to the unique registration system on clinical outcomes that Xpert Clinic uses. This leads to very small confidence intervals in the main analysis, where clearly trends on a volume-effect are lacking. Several limitations of our study should, however, also be considered. The major limitation of our study is the surgeon cohort in which all the procedures were performed, that is, a cohort of surgeons who are highly specialized and the procedures being carried out in highly specialized centers. On the other hand, there was still a wide range (6 to 163) in number of CTRs performed by each of the participating surgeons. In addition, it has been recognized that endoscopic CTR has a steep learning curve^{27–29}. Considering the complexity of this procedure compared to open CTR³⁰, the learning curve for open CTR might flatten out at a relatively early stage, that the surgeons in our cohort had already passed. Furthermore, since all the procedures were performed within one group of uniformly organized clinics with a similar patient population, we could not account for a potential hospital volume-outcome relation. Previous studies have shown an association between hospital volume and patient outcome beyond surgeon's experience; the relation between the number of patients undergoing a specific surgery at a specific hospital and their postsurgical outcomes indicate

that larger-volume hospitals yield better patient outcomes, despite individual surgeon volume^{3,31}.

In conclusion, our study shows that specialized hand surgeons have similar patient outcomes following open CTR and their annual volume does not influence patient outcome. However, whether our results apply to orthopedic surgeons, neurosurgeons and plastic surgeons in general and for example to residents and nurse practitioners still has to be investigated in further studies.

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Figure 1.
Subject selection flow chart.

Figure 2. Distribution of number of CTRs performed per year (y-axis)) per participating surgeon within the cohort (x-axis).

Figure 3.

A) Mean Symptom Severity Score (SSS) and B) Mean Functional Status Score (FSS) preoperatively and at 6 weeks, 3 months, and 6 months postoperatively in patients undergoing open CTR grouped. Outcomes are divided by whether the surgeon was a: low, medium or high volume surgeon for this procedure. Error bars represent one standard deviation.

Figure 4.

VAS overall pain preoperatively and at 6 weeks, 3 months, and 6 months postoperatively in patients undergoing open CTR. Outcomes are divided by whether the surgeon was a: low, medium or high volume surgeon for this procedure. Error bars represent one standard deviation.

Table 1

Demographic, clinical and procedural characteristics of the CTR cohort.

	Total cohort (N= 1345 patients)
Age, years (SD)	54 (13)
Female (%)	986 (73)
BMI (SD)	27 (5)
Smoking status (smoker: yes) (%)	263 (20)
Alcohol use (drinker: yes) (%)	776 (58)
<i>Comorbidities (%)</i>	
Diabetes Mellitus	68 (5.1)
Rheumatoid Arthritis	19 (1.4)
Dupuytren's disease	30 (2.2)
Trigger fingers	190 (14)
CMC1-arthritis	93 (6.9)
Compression Neuropathy	81 (6.0)
Tendinitis	38 (2.8)
History of wrist trauma	43 (3.2)
'Other'	33 (2.6)
<i>Concomitant procedures (%)</i>	
CTR + Trigger Finger Release	122 (9.1)
CTR + Cubital Tunnel Release	29 (2.2)
CTR + Guyon Release	23 (1.7)
CTR + Radial Tunnel Release	8 (0.6)
CTR + fasciotomy Dupuytren	9 (0.7)
CTR + 'other' procedure	21 (1.6)

CTR= Carpal Tunnel Release

The group 'other' comorbidities refers to STT arthritis, radiocarpal arthritis, peripheral neuropathy, cervical radiculopathy and ulnocarpal impingement.

Table 2

Uni- and multivariable analysis for association between annual surgeon volume (continuous variable) and the three outcome measurements: Symptom Severity Score (SSS), Functional Status Score (FSS) and Visual Analog Scale (VAS) overall pain at 6 months postoperatively.

Dependent variables	Unadjusted model [†] β (95%, CI) for annual surgeon volume effect	Adjusted model* β (95%, CI) for annual surgeon volume effect
BCTQ: SSS	.000 (−.001 – .001)	−.000 (−.001 – .001)
BCTQ: FSS	.000 (−.001 – .001)	−.000 (−.001 – .001)
VAS: overall pain	.006 (−.025 – .037)	−.002 (−.027 – .023)

CI, confidence interval

[†]Unadjusted model: univariable analysis for the association between annual surgeon volume and patient outcome.

* Adjusted model: adjusted for score at intake for respective questionnaire, age, sex, smoking status, alcohol use, concomitant procedure, comorbidities: diabetes mellitus, rheumatoid arthritis, CMC1-arthritis, Dupuytren's disease, trigger fingers, tendinitis, history of trauma of the wrist, compression neuropathy, and the group 'other' comorbidity.