

## Functional Results after Carpal Tunnel Endoscopic Release on a Public Health Out-Patient Surgical Campaign.

### *Resultados funcionales tras liberación endoscópica del Túnel del Carpo, en una campaña quirúrgica de salud pública.*

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Recibido: 13 de Diciembre de 2017

Aceptado: 16 de Mayo 2018

**Conflicto de intereses:** Se declara que no existe ningún tipo de conflicto de intereses con ninguno de los autores.

#### Key words:

Carpal Tunnel Syndrome/surgery\*, Decompression, Surgical/methods\*  
Endoscopy/methods

#### Palabras clave:

Síndrome/cirugía del túnel del carpo\*, Descompresión Quirúrgica/métodos\*, Endoscopia/métodos\*

#### Abstract.

**Purpose.** Carpal tunnel syndrome (CTS) is the most common type of compressive neuropathy. Its main manifestations are paresthesias and dysesthesias over the median nerve territory on the hand. CTS is a ubiquitous public health problem and frequently causes disability. Endoscopic release is a good alternative to CTS. We aim to evaluate both the benefits of CTS diagnosis in the primary care system, and the benefits of using an outpatient surgery for CTS. An additional goal was to generate current national statistics regarding early diagnosis, functional outcome, and prognosis of median nerve compression treated with endoscopic carpal tunnel release (ECTR).

**Methods.** In a collaboration with Mexican public health institutions, we designed a self-controlled, longitudinal, prospective study focusing on the early detection and surgical treatment of CTS. A preoperative assessment was conducted on 56 patients based on medical history, physical examination, dynamometry, and functional scales including DASH, Mayo, Michigan, and visual pain analog. Thirty-six adult patients were treated surgically with ECTR and followed for up to 16 months. **Results.** All study time points were collected on 23 patients. This self-controlled study showed statistical improvements in pain symptoms (92.4%,  $p$  0.0001), muscle strength, and functional questionnaires DASH (66.1%,  $p$  0.0001), Mayo (48.2%,  $p$  0.001) and Michigan (91.3%,  $p$  0.0001) in patients treated with ECTR compared to patients' baseline measurements before surgery. At the second follow-up visit, only one complication was reported in the 36 patients with follow-up data. **Conclusion.** ECTR shortened the recovery time and improved functional outcomes in patients. While more clinical research is needed to fully demonstrate the utility of ECTR for treatment of CTS in public health cases, this study showed that lack of access to tertiary care hospitals is not an impediment to providing CTS treatment. Implementation of training programs at local hospitals with up-to-date training on diagnostics and treatment improves the prognosis of patients with CTS.

#### Resumen.

**Objetivo.** El síndrome de túnel del carpo (STC) es la neuropatía por compresión más frecuente, cuyos principales síntomas son parestesias y disestesias sobre el territorio inervado por el nervio mediano en la mano. El STC es un problema ubicuo de salud pública que con frecuencia causa discapacidad. La liberación endoscópica del túnel carpiano es una buena alternativa de tratamiento. Los objetivos del estudio fueron evaluar tanto los beneficios del diagnóstico desde el primer nivel de atención, así como el uso de cirugías extramuros para el tratamiento del STC. Un objetivo adicional fue generar estadísticas nacionales actuales acerca del diagnóstico temprano, resultado funcional y pronóstico en compresiones del nervio mediano tratadas con liberación endoscópica del túnel del carpo (LETC). **Métodos.** En una colaboración interinstitucional del sistema de salud mexicano, se diseñó un estudio autocontrolado, prospectivo y longitudinal centrado en la detección temprana y tratamiento quirúrgico del STC. Se realizó una evaluación preoperatoria en 56 pacientes basados en antecedentes, exploración física, dinamometría y escalas funcionales que incluyeron DASH, Mayo, Michigan y la escala visual análoga de dolor. Treinta y seis pacientes adultos fueron tratados quirúrgicamente con LETC, con seguimiento hasta de 16 meses. **Resultados.** Veintitrés pacientes concluyeron todas las etapas de estudio. Este estudio autocontrolado mostró mejorías estadísticas en dolor (92.4%,  $p$  0.0001), fuerza muscular en la extremidad afectada cuestionarios funcionales DASH (66.1%,  $p$  0.0001), Mayo (48.2%,  $p$  0.001) y Michigan (91.3%,  $p$  0.0001) en pacientes tratados con LETC al ser comparados con las mediciones basales del paciente antes de la intervención quirúrgica. En la segunda visita postoperatoria, únicamente se reportó una complicación en 36 pacientes con seguimiento (2.8%).

**Conclusión.** La LETC acortó el tiempo de recuperación y mejoró los resultados funcionales en los pacientes. Aun cuando se necesitan más estudios clínicos para demostrar completamente la utilidad de la LETC en el tratamiento del STC en salud pública, este estudio mostró que la falta de acceso a hospitales de tercer nivel de atención no presenta un obstáculo para proporcionar tratamiento afectivo al STC. La implementación de programas de entrenamiento en hospitales locales con técnicas actualizadas para el diagnóstico y tratamiento mejora el pronóstico de los pacientes con STC.

### Introduction

Carpal tunnel syndrome (CTS) is a compressive neuropathy affecting the median nerve at the wrist. Its main pathophysiology is defined as an increase of pressure inside a closed space<sup>1</sup>. Patients report constant or intermittent numbness and paresthesias in the median nerve sensitive distribution. Sleep disruption is also common<sup>2</sup>, and occasionally can be accompanied by pain. Severe cases present with thenar muscle denervation, weakness, and atrophy<sup>3</sup>. CTS is the most common nerve compression syndrome in the general population with 0.1%-10% prevalence.<sup>4</sup> It's more frequent in women between 40 and 60 years old with a 7:1 ratio.<sup>5</sup> Several risk factors are associated with CTS (Table 1); however, in ~95% of cases, CTS is idiopathic.<sup>4</sup> An estimated 6.7% of workers have CTS, with an annual incidence of 3.1%.<sup>6</sup>

Foremost, CTS diagnosis is based on the patient's symptoms and physical examination. CTS is accurately diagnosed in 86% of cases with nocturnal pain, positive monofilament and *Durkhan* tests, and a classic or probable *Birgham* diagram test result.<sup>7,8</sup> The presence of *Phalen* and *Tinel* tests, plus scratch collapse test, increases the diagnosis sensibility up to 64%, with a specificity of 99%.<sup>9</sup> Electrodiagnostic studies confirm the clinical findings.<sup>10</sup>

Table 1. Risk factors for CTS

Obesity
Hypothyroidism
Myxedema
Diabetes
Inflammatory arthritis
Kidney disease
Acromegaly
Mucopolysaccharidosis
Pregnancy
Genetic predisposition
Advanced age
Smoking
Labor stress
Extreme or repetitive wrist flexion and repetitive use of vibrating hand tools
Tenosynovitis
Hematoma
Displaced bone fragments after adjacent fracture or dislocation
Distal radius malunion

Initial treatment for CTS is non-surgical with lifestyle modification and the use of night orthosis. The administration of local infiltration with steroids or oral NSAIDs could also provide temporary relief.<sup>11</sup> Surgery indications include neurological impairment, severe symptoms at diagnosis, thenar weakness, atrophy or electrodiagnostic evidence of denervation.<sup>12</sup> Several complications are reported with different surgical techniques, including those with specialized instrumentation.<sup>13-16</sup> Interestingly, in many cases, endoscopic release resulted in better functional outcomes and a quicker return to work.<sup>17-22</sup> The incidence of persistent symptoms after carpal tunnel release varies from 1% to 25%.<sup>23</sup> Causes of symptom persistence include incomplete release of the transverse carpal ligament, incorrect diagnosis, double crush syndrome, peripheral neuropathy, a lesion inside the carpal tunnel and median nerve iatrogenic injury.<sup>15, 24</sup>

The endoscopic technique allows for a complete transection of the transverse carpal ligament, as an outpatient minimally invasive procedure.<sup>15</sup> With an endoscopic two portal approach<sup>25,26</sup> the surgeon needs to switch between the endoscope and blade from portals; meanwhile a simpler single portal technique<sup>27</sup> is as effective as the open technique if performed correctly, it is safe and obviates the use of a second portal.<sup>14</sup> Faster recovery of both grip and pinch strengths have been reported.<sup>28</sup> Endoscopic release decreases the risk of tendon bowstringing, and causes a faster return to work and daily activities, when compared to open release.<sup>22</sup> The indications for endoscopic treatment are similar to the open release.<sup>29</sup> Routine motor branch exploration, epineurotomy, neurolysis and flexor synovectomy are now widely considered unnecessary making ECTR more suitable.<sup>30</sup>

CTS is a public health problem that mostly affects working age people; the lack of a health system capable to detect CTS and provide adequate treatment notably affects the society.<sup>31-34</sup> The suburban and agricultural<sup>32</sup> areas are not exempt of developing CTS. Even though there are prevalence studies of CTS in mestizo and indigenous groups in Mexico,<sup>35,36</sup> there is no study regarding early detection, treatment and outcome of CTS in a specific Mexican health care system.

## MATERIALS AND METHODS

The present study was part of a established public health outpatient surgical campaigns internal program of the National Institute of Rehabilitation, Federal Government Ministry of Health, with approval of the Internal Research Board of the Institute, in collaboration with the health authorities of the Mexican State of Campeche. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients for being included in the study.

The aim of the program was the implementation of surgical campaigns that include local health personnel training regarding the diagnosis and treatment of CTS. The participation of specialized hand surgeons and the use of advanced surgical techniques allow for early detection, improve the patients' prognosis, and provide a faster recovery and return to the patients' regular activities. We also aim to objectively evaluate the results of a campaign focused on early detection, out-patient treatment, and follow-up of patients with CTS and other compressive neuropathies of the upper limb. It will also help to develop current and relevant national statistics about the functional outcome and prognosis of nerve compression when detected early and treated with endoscopic carpal tunnel release (ECTR), followed by immediate local rehabilitation.

During this study we tried to answer if ECTR is an advantageous surgical treatment for a public health population compared to the open CTR, which we know offers satisfactory functional outcomes. We hypothesized that the ECTR release improves strength, sensibility, symptoms and functional status in a cohort of patients with CTS and that ECTR will be cost-effective to the public health in Mexico. We also hypothesized that postoperative functional outcome is related to the severity and duration of symptoms, with better improvements to patients with mild symptomatology and less time with the compression.

Specific objectives: 1) To evaluate strength and sensibility changes before and after surgery. 2) To evaluate analog visual scale changes (pain, quality of life and depression). 3) To evaluate functional outcome scale changes from before to after surgery (DASH, Mayo, Michigan). 4) To compare evolution time and symptoms severity with functional outcome.

Study design: Self-controlled study, longitudinal, prospective, observational, descriptive. Work universe: patients 18 years old or older; male and female patients who were diagnosed with CTS and meet the inclusion criteria to receive surgical treatment consistent with ECTR during an extramural surgical campaign.

Inclusion criteria: 1) Patients 18 years old or older. 2) Patients with symptoms compatible with CTS. 3) Completion of the Questionnaire for Pain Assessment. 4) Positive diagnostic tests for CTS. 5) Patients who accept an informed consent to enter the study. Exclusion Criteria: 1) Patients with traumatic or degenerative orthopedic pathologies of the affected limb. 2) Patients with previous open or endoscopic surgical treatment for carpal tunnel on the affected limb. Elimination criteria: 1) Failure to attend postoperative follow-up visits. 2) Incomplete preoperative studies. 3) Incomplete preoperative scores. 4) An incomplete medical chart.

The variables considered were gender, age, side of the body affected, dominance, and the evolution time from the beginning of symptoms to the surgical intervention. The data was collected using the following quantitative continuous scales: Mayo wrist score,<sup>37</sup> DASH score,<sup>38</sup> Michigan Hand Outcome Questionnaire,<sup>39</sup> Visual Analog Scale (VAS) for Pain,<sup>40</sup> VAS for Quality of Life, VAS for Depression, and the measurement of muscle strength using the Dynes scale.

Patient evaluation: Candidates for surgery were detected with the application of a modified Questionnaire for Pain Assessment of Mackinnon and Novak<sup>1</sup> during the general or orthopedic consultation of the state's DIF [(Desarrollo Integral de la Familia (Integral Family Development Bureau)] system on the municipalities of Campeche, Champotón, Calkini and Carmen. A total of 56

patients were referred from their primary care physician with a positive Questionnaire for Pain Assessment test and were evaluated. Patients evaluated ranged from 16 to 75 years old, with an average age of 47.8 years old. There were 48 female patients and 8 male patients. The evaluation of patients with probable CTS was performed by two hand surgeons and one hand surgery fellow.

Fifty-six patients were assessed, and forty-eight patients were scheduled for ECTR. Eight patients were not eligible. The initial assessment consisted of obtaining patient data, including the patient's dominant hand, occupation, past medical history, and risk factors (Table 2). The physical examination included dynamometry tests (G200 Dynamometer, P200 Pinchmeter & Grip Strength and Pinch Strength evaluation and exercise software, Biometrics LTD. Ladysmith, VA, USA) for grip, key pinch, three-tip pinch and tip-to-tip pinch, comparative sensibility and two-point discrimination, elicitation of Tinel, Phalen and Durkan signs, and a scratch collapse test. The Mayo Wrist Scale was also performed during the physical examination. All the results were registered in a data capture sheet and were recorded during all three follow-up visits. Patients also completed the Questionnaire for Pain Assessment of Mackinnon and Novak, Michigan Hand Outcome Questionnaire, and the Disabilities of the Arm Shoulder and Hand Score (DASH). The same tests were repeated and registered during the follow-up visits. The review of the electrodiagnostic studies were also included. When required, additional studies were performed, including blood chemistry panel, thyroid function test, X-ray, and CT scan for differential diagnosis purposes. Of the 48 patients programmed for endoscopic carpal tunnel release, ten patients withdrew from the study, and two patients were suspended for anesthetic contraindication caused by an upper airway infection the surgery day.

Thirty-six surgical interventions were performed using ECTR equipment with the Agee technique, endoscopic towers, pneumatic ischemia devices, and regional anesthesia. In these patients, twelve had correlated pathology as follows: four open A1 pulley releases, five open cubital tunnel releases and three open pronator teres releases were

<b>Table 2. Demographics on surgically intervened patients. (n=36)</b>	
	<b>Number</b>
<b>Sex</b>	
Female	32
Male	4
<b>Grip strength difference</b>	
Intervened/Non-intervened(100%)	85.9%
<b>Hand dominance</b>	
Right-handed	35
Left-handed	1
<b>Hand surgically intervened</b>	
Right	22
Left	14
	<b>Mean, (range, SD)</b>
Age, years	50.6 (33-75, 10.3)
Evolution of symptoms, months	37 (1-360, 55.7)
Nocturnal pain, days per week	5 (0-7, 2.1)
	<b>Number</b>
<b>Occupation</b>	
House-wife	17
Secretary/clerk	2
Teacher	5
Physician/nurse	4
Hair dresser	2
Others*	6
<b>Concomitant diseases</b>	
DM 2	7
HAS	6
Thyroid	3
others	5
*(embroiderer, journalist, sacristan, federal employee, unemployed, mechanic)	

scheduled. For the ECTR a 2-to-3-centimeters transverse cutaneous incision was made on the proximal wrist fold, between the *palmaris longus* and the *flexor carpi ulnaris* tendons. Using a wide longitudinal dissection, the cutaneous nerves were protected and the antebrachial fascia was identified.<sup>41</sup> A distally-based fascial antebrachial flap was dissected in a "U" shape and was elevated in the palmar direction. A probe was inserted underneath the ulnar side of the carpal tunnel, radial to the hook of the hamate. The wrist was slightly extended, followed by the insertion of the carpal tunnel release

system handle (© MicroAire Surgical Instruments, LLC. 3590 Grand Forks Blvd, Charlottesville, VA. 22911) with a vision window towards the ulnar side of the flexor retinaculum. The surgeon's contralateral hand then palpated the tip of the handle. With visualization, the distal limit of the flexor retinaculum was identified. Once we were sure of the correct position, the blade was elevated, and the handle was extracted by cutting the distal half of the flexor retinaculum. The handle was then reinserted to review the partial release and the blade was activated to cut the remnant portion of the flexor

retinaculum. Using tenotomy scissors, the proximal antebrachial fascia was released proximally to the cutaneous incision. The skin was closed and a volar antebrachial splint was used postoperatively.<sup>15</sup> Agee recommends that if the surgeon would not be able to obtain a direct visualization, then the endoscopic technique must be abandoned and the tunnel must be released with an open procedure.<sup>14</sup> In our series, no procedure needed to be converted.

Three follow-up visits were performed. During the postoperative follow-up visits, all of the tests and questionnaires were repeated. The DIF carried out the rehabilitation program.

**STATISTICAL ANALYSIS:** Four groups were created: 1) right-handed patients with unilateral CTS; 2) left-handed patients with unilateral CTS; 3) patients with bilateral CTS with the right hand surgically intervened, and 4) patients with bilateral CTS with the left hand surgically intervened. Descriptive statistical tests were performed. Quantitative variables were expressed with central tendency measurements and dispersion measurements. Categorical and ordinal variables were expressed using frequencies and ratios. The differences in dynamometrics, special tests, and functional scale results were analyzed using a chi-square test and a

Fischer's exact test. A t-test for related samples and a Friedman test were used as alternatives to a one-way ANOVA with repeated measures. Hotelling's T-squared statistical test was used for the interaction analysis of evolution contrast analysis with an ANOVA. A p-value <0.05 was considered to be statistically significant.

## RESULTS

Thirty-two female and four male patients had surgery, with an average age of 50.6 years old. Hand dominance included 35 right-handed patients and 1 left-handed. The average preoperative symptomatic time was 37 months. The mean number of nights per week with symptoms was 5. Grip strength difference between affected. Hand non-affected hands was 85.9%. Comorbidities included 8 patients with hypertension (17.8%), 6 with DM2 (13.3%) and 3 with hypothyroidism (6.7%). Three

OR tables worked simultaneously, 28 right and 17 left hands were operated. Additionally, hand ipsilateral complaints included four flexor tendon tenosynovitis, five cubital tunnel syndrome cases, and three pronator teres syndrome cases (6.7%) (Table 3). No complications occurred during the procedures.

Every patient was reviewed at the first visit; three patients presented with edema and wound tenderness and one patient presented with ring ulnar digital nerve paresthesia. The second follow-up visit was conducted six weeks after surgery, with 92% patient attendance. All but one of the reported complications were resolved at the second visit. Sixty-four percent (23 patients) completed the third follow-up visit, 16 months post-operation with no complications reported (Figure 1).

During the analysis, we found differences between genders regarding grip strength, representing the only variable sensible to changes before and after surgery (Table 3). The mean grip strength difference between the intervened vs the non-intervened hand showed an important recovery progression during the measurements. During the first measurement, we registered the basal preoperative condition of strength. This observation showed that the patients that had surgery on their left hand had the bigger difference in grip strength, 19.1% less when comparing the mean grip strength of the intervened vs the non-intervened patients. In the cases with bilateral symptomatology, the differences between the intervened and the non-intervened hand were less important (Table 4).

During the measurement performed at the 1st follow-up, the intervened hands experienced loss of grip strength, demonstrating a difference between the intervened hand vs the non-intervened with an approximate mean loss of 75%. The third measurement showed a grip strength mean loss of 37%. Lastly, the fourth measurement showed an improvement in grip strength in all groups, when compared with the preoperative measurements (Table 4). Outstandingly, our results show that at 16 months surgeons can expect an objective improvement on wrist strength after an ECTR (Figure 2). Complications were related to four fibrous scar

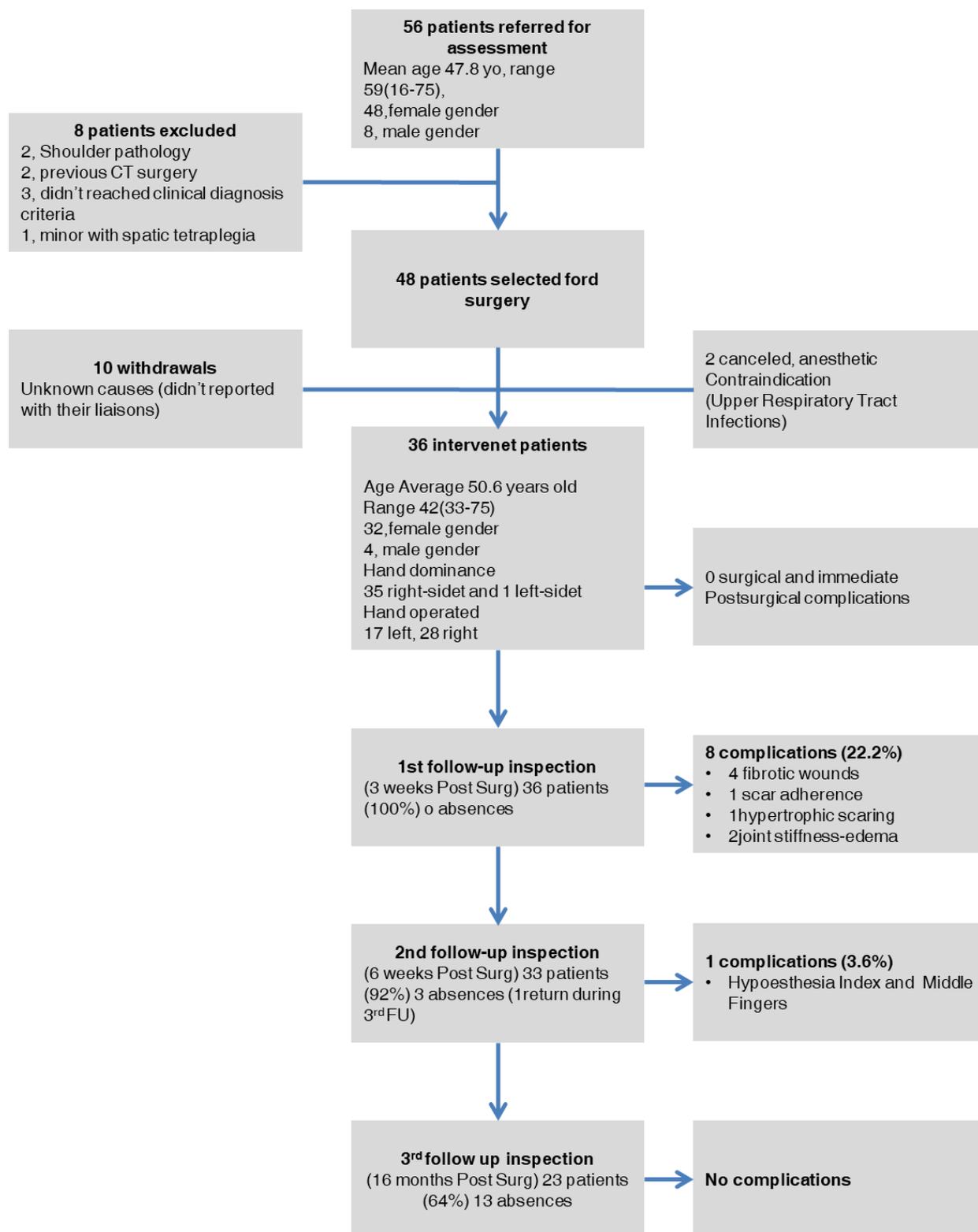


Figure 1. Public Health Campaign Endoscopic CTR Results Flow Chart.

**Table 3.** Preoperative grip strength distribution according to patients' gender

Affected Hand	Hand Status	Grip Strength [Dynes. Mean, (SD)]		p-value
		Female	Male	
Right	Right hand intervened	14.4 (2.7)	17.7 (5.8)	0.70
	Left hand healthy	17.7 (7.5)	31.5 (2.4)	<b>0.03</b>
Left	Left hand intervened	16.2 (6.9)	35.0 (0.0)	<b>0.03</b>
	Right hand healthy	20.3 (2.6)	40.4 (8.2)	<b>0.04</b>
Bilateral	Right intervened	14.8 (2.6)	27.8 (8.2)	<b>0.04</b>
	Left symptomatic	15.8 (5.5)	33.2 (0.0)	<b>0.01</b>
	Left intervened	18.4 (10.8)	-	-
	Right symptomatic	19.0 (7.0)	-	-

ng wounds, one wound adherence injury, and one hypertrophic wound; two patients had stiffness and postoperative edema that resolved with physical therapy. No neurovascular, tendinous injuries or infections were observed.

Overall, we found significant differences regarding pain, quality of life, and absence of depression after ECTR. All functional scales showed improved results. The functional recovery was related to age,

but not to evolution time or severity of symptoms as we initially thought. We also found improvement of the muscle strength with tendency to recovery in all four groups (Table 5).

### DISCUSSION

This was a prospective, self-controlled,<sup>42</sup> clinical study, and was part of a government out-patient surgical program that did not allow randomization.

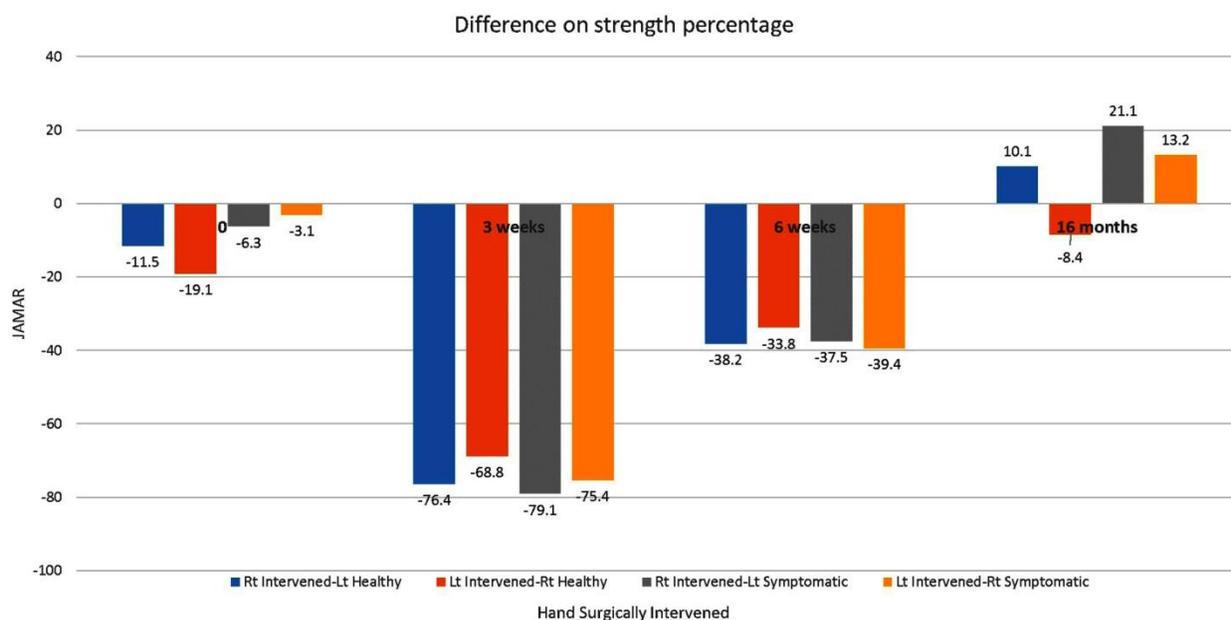


Table 4. Patients bilateral grip strength evolution during the follow up

Encounter	Rt int M (SD)	Lt ealthy M (SD)	Dif %(p*)	Lt int M (SD)	Rt healthy M (SD)	Dif %(p*)	Rt int M (SD)	Lt symp M (SD)	Dif %(p*)
PIA	14.6 (6.8)	16.5 (6.4)	-11.5 (0.03)	16.2 (6.9)	20.3 (8.3)	-19.1 (0.002)	14.8 (5.2)	15.8 (5.5)	-6.3 (0.32)
1 <sup>st</sup> F/up	4.0 (2.6)	17.0 (6.4)	-76.4 (0.0001)	6.7 (5.3)	20.6 (6.1)	-68.8 (0.0001)	3.3 (2.0)	15.8 (5.0)	-79.1 (0.0001)
2 <sup>nd</sup> F/up	11.3 (3.9)	18.3 (6.5)	-38.2 (0.0001)	11.6 (4.4)	19.7 (8.5)	-33.8 (0.005)	11.3 (3.7)	18.1 (6.2)	-37.5 (0.002)
3 <sup>rd</sup> F/up	18.4 (5.9)	16.7 (6.3)	+10.1 (0.11)	19.4 (4.5)	21.7 (7.0)	-8.4 (0.09)	20.6 (6.1)	17.0 (7.2)	+21.1 (0.11)
p**	0.001	0.17	0.0001	0.004	0.17	0.01	0.02	0.12	0.007

PIA = Pre-operative initial assessment, F/up = Follow-up, Rt = right, Lt = left, int = surgically intervened, symp = symptomatic, Dif = difference, M = mean, SD = standard deviation, p = p-value, \*difference comparing sides, \*\* same side change during time

In this study, we found statistical improvement of symptomatology, muscle strength, and functional outcome in the patients treated with ECTR, with similar complication rates to those reported in the literature.<sup>22,43</sup> As a highlight of this work, after an ECTR patients can be advised that during the next twelve to sixteen months will obtain a recover of wrist strength. In addition, the younger the patient the better functional result that can be expected.

Adequate treatment of carpal tunnel syndrome, when performed by trained surgeons using minimally invasive techniques, statistically reduces the recovery time and the waiting time for return to daily living activities. This approach also significantly improves functional outcomes and symptoms. Although there are still some concerns among Mexican surgeons regarding the cost of the endoscopic procedure and the use of the specialized equipment,<sup>44</sup> these concerns could be alleviated with further training on this technique and equipment availability. Likewise, additional training is the only way to improve the learning curve for young surgeons wishing to gain more exposure to this procedure. There is also a need for a cost-benefit study to demonstrate the technical and economic advantage of this endoscopic technique, even though with these efforts, the access to adequate treatment for rural, far away communities pose a challenge to resolve yet. The use of international multicentric research would allow surgeons and researchers to increase the external validity of the trials, and compare the results when considering cultural, ethnical and work-related considerations. However, studies have been published demonstrating the safety and efficacy of open carpal tunnel surgery using field sterility alone and local anesthesia with large cohorts of patients.<sup>45-47</sup> Overall, this seems to be a better strategy in terms of resource management but needs to be extrapolated to the Mexican Health Care System. As a benefit, we have shown that the lack of access to third-level hospitals is not an excuse for not being able to provide an accurate diagnosis and treatment plan for upper limb compressive neuropathy.

Ultimately, the implementation of surgical campaigns that includes the local health system, the

training of local specialists on current diagnostic tools and treatment plans for CTS would improve the prognosis of patients with this pathology, independently of the surgical technique used. We think cost-effectiveness with ECTR is worth it in terms of overall savings including earlier return to work, done as an ambulatory procedure during surgical outpatient campaign, with surgeons well trained in surgical treatment to avoid complications, in a public health system with limited material and human resources.

### Acknowledgements

Dr. Lourdes Couoh and all the health care team at DIF Campeche and the "Cirugia Extramuros" program at the National Institute of Rehabilitation, Ministry of Health, Mexico. Surgical team especially Surgical Nurse Concepcion Mata Ramirez. Mrs. Millicent Horn, BS, Mrs. Carter Baughman, BS and Christina Kaufman, PhD for writing assistance.

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