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REVIEW ARTICLES OF TOPICS

Outcomes of open and endoscopic carpal tunnel release: a meta-analysis

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Abstract
Background Currently, there are two genres of surgical treatment of carpal tunnel syndrome, open versus endoscopic. The goal of our study is to analyze published data by comparing outcomes of surgical treatment for carpal tunnel syndrome and determine if one approach is superior to the other (open versus endoscopic).
Methods A meta-analysis of retrospective series of Carpal tunnel release including >20 patients, with results measuring outcomes based on at least six of the following nine parameters (paresthesia relief, scar tenderness, two-point discrimination, thenar muscle weakness, Semmes–Weinstein/SW monofilament testing, return to work time, grip and pinch strength, and complications).
Results Endoscopic carpal tunnel approach showed statistically superior outcomes in eight of the nine categories investigated. Only in the category of complications (mean occurrence of 1.2 % in the open release versus 2.2 % in the endoscopic release group) was the endoscopic group inferior.
Conclusion This suggests that the endoscopic release is superior to the open release, particularly in experienced hands.

Keywords Carpal tunnel syndrome · Endoscopic carpal tunnel release · Outcomes

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Introduction

Carpal tunnel syndrome (CTS) is a common compression neuropathy of the median nerve [22] predominantly presenting as symptomatic dysesthesias in the distribution of the sensory digital nerves [1]. A variety of non-surgical and surgical approaches for CTS treatment have been advocated [1, 22, 27]. Variants of open and endoscopic carpal tunnel release (CTR) technique remain the mainstay of the surgical treatment [1]; however, more outcome data is needed to validate superiority of one technique over another [16, 39]. Endoscopic CTR (ECTR) has been shown to result in a more rapid recovery and superior early functional outcome; however, this approach has been associated with a higher rate of complications, ranging from temporary to permanent nerve, vessel, and tendon injury [12, 16, 27, 39]. To evaluate the power of evidence behind notions that one of the modalities is superior over another, a meta-analysis of studies comparing outcomes of the two techniques was undertaken [30, 33].

Methods

Twenty-two studies [2–5, 7, 9, 11, 13–19, 21, 24–26, 31, 34, 35, 40, 42] published in peer reviewed journals from 1966 to 2003 were identified with "Medline" which met criteria of high relevance and quality [42]. Prospective randomized controlled and retrospective studies were selected if they included at least

20 patients, where the principal intervention involved surgery, and with a follow-up of at least three (average of six) of the selected nine CTR outcome parameters: (1) paresthesia relief, (2) scar tenderness, (3) two-point discrimination, (4) thenar weakness, (5) SW monofilament testing, (6) return to work time, (7) grip strength, (8) pinch strength, and (9) complications (Table 1) for at least 6 months. The total number of patients included into this analysis was 4,178. Variants of endoscopic procedures (single portal and double portal techniques) were grouped together as "endoscopic CTR". Using a statistical method of comparing means of means and relating these values to the number of treated patients (hands) according to the formula presented in Eq. 1, the favorable result in selected CTS treatment outcome categories was determined [30, 39] (Table 1). Specifically, a standard weighted mean derivation technique was used to estimate the overall statistical mean for each parameter (Eq. 1). Each mean was weighted by the reciprocal of its standard error. The mean values from the two groups were then compared using a Z test, which generated p values shown in Table 1. A p value less than 0.05 was considered significant and an evidence of significant difference between variables [36, 37].

$\rho' =$ mean parameter value from study
$\rho'' =$ mean of means
$\mathrm{n} =$ number of hands in study
$\mathrm{N} =$ number of hand for entire group
$\sigma(\rho) =$ Standard Error of ρ
$\mathrm{Z} = \mathrm{z} -$ value
$\sigma(\rho) = \sqrt{(\rho(1-\rho)/\mathrm{n})}$
$\rho' = \dfrac{\sum(\rho/(\sigma(\rho))}{\sum(1/\sigma(\rho))} \qquad \rho' = \dfrac{\sum(\rho/(\sigma(\rho))}{\sum(1/(\sigma(\rho))}$
$\mathrm{Z} = \rho''_{\mathrm{E}} - \rho''_{\mathrm{O}} / \sqrt{[(\sigma_{\mathrm{E}}/\mathrm{N_E}) + (\sigma_{\mathrm{O}}/\mathrm{N_O})]}$

Subscript E and O signify
Endoscopic and Open (respectively)

(1)

Results

The results of the meta-analysis demonstrated that the endoscopic approach had statistically significant outcome superiority in eight out of nine categories investigated. This included: paresthesia relief, scar tenderness, two-point discrimination, thenar weakness, SW monofilament testing, return to work time, grip strength, and pinch strength. The open release showed a statistically significant superiority to that of the endoscopic release only in the category of the complications rate, with a mean occurrence of 1.2 % in the open group versus 2.2 % in the endoscopic group. Overall results of the comparative analysis are depicted in Table 1.

Discussion

Carpal tunnel syndrome was described by Sir James Paget in 1853, and since then, CTR of the transverse carpal ligament is one of the most commonly performed procedures in USA [29, 38]. However, the preferred surgical approach has continued to be surrounded by controversy for several decades.

Table 1 Comparative analysis of endoscopic and open carpal tunnel release

Parameter	Open method, *n*	Open method, *X* (%)	Endoscopic method, *n*	Endoscopic method, *X* (%)	Favorable outcome	*p* value
Paresthesia relief (% with relief)	1,588	79.3±1.02	2,590	85.0±0.75	E	<0.0001
Scar tenderness (% with any tenderness present)	413	23.1±2.06	813	14.8±1.25	E	<0.0001
Two-Point discrimination (% Abnormal)	281	29.6±2.72	535	9.09±1.24	E	<0.0001
Thenar weakness (% with any weakness)	644	25.3±1.71	851	0.907±0.98	E	<0.0001
SW monofilament (Return to normal)	292	53.1±2.92	350	67.1±2.51	E	<0.0001
Return to work time	110	21.8±0.70 days	2,382	15.32±0.19 days	E	<0.0001
Grip strength (%=postop/preop kg or lbs)	1,112	104.3±1.32	1,438	106.4±0.98	E	<0.0001
Pinch strength (%=postop/preop kg or lbs)	912	111.7±0.90	1,343	127.9±0.96	E	<0.0001
Complications[a]	207	1.20±0.75	2,215	2.17±0.33	O	=0.017

Values are based on approximately 6-month evaluation time

[a] Complications include nerve/artery/tendon injury, recurrence or incomplete release, and wound complications

E Endoscopic technique, *O* Open technique

Currently, several different approaches are used to surgically release the transverse carpal ligament. These include the standard open technique, with minor variants based on limited incisions, and the ECTR introduced by Okutsu and modified by Chow to a two-portal technique [6, 28]. Since its introduction, the ECTR approach has undergone much scrutiny and criticism over its effectiveness and safety compared to that of the open technique [9, 32, 39, 42].

Comparative analysis of CTR procedures should include the following factors: outcome measurement parameters, operative technique, and learning curve. Comparing analysis of multiple study results is difficult due to varying outcome parameters between studies, also units of measurement and data collection times are not standardized [39]. In this study, parameters that were repetitively used in a large series of papers were identified and used as basis for comparison. Parameters and their respective units varied from study to study. Therefore, two studies may have both evaluated return to work but one would have presented their results in days, while the other presented the results in percent of function returned. For this reason, data measured in different units were excluded to help avoid introduction of bias created by rescaling data into common units. This exclusion criterion could introduce a selection bias; however, by proceeding with this as a standard exclusion criteria, the bias is minimized. Furthermore, this minimal selection bias is far outweighed by the bias that would be created through rescaling the data [30].

Variation in technique among authors is another important factor to consider. There are two basic approaches: open CTR (OCTR) versus ECTR with multiple minor variants in technique [2–5, 7, 9, 11–19, 21, 22, 24–27, 31, 34, 35, 40, 42]. The first OCTR paper was published in 1933 by Learmonth using a long lazy-S incision to traverse the palmar wrist crease and ensure complete division of the transverse carpal ligament and the distal aspect of the deep anterior antebrachial fascia [20]. This procedure carried with it a significant morbidity attributed to the large incision. Thus, leading to the development of endoscopic methods [1, 2, 5, 11–17, 19, 22, 27, 40, 42]. Klein proposed that endoscopic release offered quicker recovery, decreased scar tenderness, and earlier return to work/daily activities. However, ECTR also presented with higher complication rates ranging from 0.43 to 24 % [8, 16]. These included iatrogenic nerve, vessel, and tendon injury attributed to limited target visualization, as well as higher rates of recurrent symptoms due to incomplete transverse carpal ligament release [3, 4, 6, 7, 16, 33, 41]. Most of these complications were demonstrated only in cadaveric studies or occurred early in the introduction of the endoscopic technique in vivo and occurred as a result of inexperienced surgeons performing this procedure. With the widespread use of this technique today, including minor variations, the complication rate has been shown to be similar to that of the open approach. For example, Tse et al. published their experience with ECTR in 1,241 wrists and documented no major complications involving nerve, vessel, or tendon injury [41].

Notably, it was pointed out that if incisions for OCTR are not large enough to examine the floor and contents of the tunnel, as well as address associated abnormalities when applicable, then disabling complications occur just as with ECTR [10, 23].

In order to combine the simplicity and safety of the traditional OCTR with the reduced tissue trauma and postoperative morbidity of endoscopic release, a limited palmar incision technique was developed. A 1-cm volar incision is made through which visualization and identification of structures can be made and the release undertaken [16, 21, 34, 41]. This method has delivered very promising results with complications at a rate of 4.7 %, but of which there were no nerve injuries and no long-term sequelae [9, 16, 21, 22, 34, 40, 42]. However, no publications from 1966 through 2006, reviewing outcome of "open minimal incision" type of CTR meeting our study inclusion criteria, were found (2006 Rab et al. study with bilateral CTR randomized to open on one side and two portal endoscopic on the other side which did not meet inclusive criteria of this meta-analysis, because there were only 10 patients and parameter data was in non-standard units, but essentially reaffirmed its conclusions) [32]. Therefore, analyzed procedures were categorized as open or endoscopic, and no subgroups were compared for the sake of greater power in the statistical analysis. Similarly, the limited incision was included with the data from traditional OCTR because there is insufficient data at this time for separate comparison of this data. As the result of shortcomings of available studies with frequent lack of specificity in group description, this meta-analysis has shortcomings too. Therefore, future studies on outcomes of CTR, for more statistical power and higher clinical relevance of meta-analyses, should stratify and delineate specific subgroups (open approach traditional, open limited incision, and endoscopic single and double portal), thereby allowing for the answer of which method is better according to statistical significance. Currently, there is an inherent error given all the procedures and techniques within one group are not identical.

The learning curve for each of the methods must be taken into consideration when evaluating results and outcome. Both techniques require proper training and experience before proficiency is reached [6, 8, 22, 23]. In experienced or careless hands, the outcomes for both techniques may be similar and have low morbidity [10, 23, 32]. Chow et al. demonstrated in one study that surgeons who have performed more than 100 ECTRs had a complication rate of <1 % compared to those who had performed fewer than 25 cases which had a complication of 5.6 % [8]. Therefore one can define experience with ECTR as having performed

greater than 100 releases. However, the open methods require less skill in the use of tools and techniques, therefore, less dependent on experience to minimize complications [2–5, 7, 9, 11–13, 16, 17, 21, 22, 24–26, 31, 34, 40, 42]. The endoscopic approach, regardless of technique, has been associated with a steeper learning curve, higher complication rate, and higher rate of incomplete release when compared to the standard open carpal tunnel approach [3, 5, 7, 9, 11, 13].

By using statistical methods to analyze the data from previous studies on carpal tunnel releases and combining the power of evidence from all these studies, a comparison with far more statistical power than any of the prior studies was completed. A p value less than 0.05 (signifying statistical significance) provided evidence of the superiority of one method over the other as demonstrated in Table 1. Completed analysis demonstrated that the endoscopic approach showed favorable outcomes in eight out of the nine categories reviewed when compared to the open approach. This was statistically significant with p values <0.001 in all of the eight categories. The open technique was shown to be superior in the category of complications with a p value=0.017. The mean complication rate was 1.2 % for the open group versus 2.2 % in the endoscopic group. This review allows for comparison and summarization of previous studies comparing open versus endoscopic approach to carpal tunnel release. Ultimately, the meta-analysis findings can be useful for developing practice guidelines and decision making.

Conclusion

Review of the literature with well-defined and uniform approach to relevant studies regarding the outcome of the CTR validates or refutes notions from non-methodical reviews. Our analysis suggests that the ECTR release has a more favorable outcome when compared to the OCTR technique with the exception of having a higher complication rate. However, in experienced hands, the endoscopic approach proves to be a safe technique with favorable outcomes.

Conflict of Interest The authors declare that they have no conflicts of interest, commercial associations, or intent of financial gain regarding this research.

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