The Royal College of Surgeons of England

Ann R Coll Surg Engl 2005; **87**: 36–40
doi 10.1308/1478708051469

Original article

Carpal tunnel syndrome, the search for a cost-effective surgical intervention: a randomised controlled trial

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***Objective*: There is insufficient evidence regarding the clinical and cost-effectiveness of surgical interventions for carpal tunnel syndrome. This study evaluates the cost, effectiveness and cost-effectiveness of minimally invasive surgery compared with conventional open surgery.**
***Patients and Methods*: 194 sufferers (208 hands) of carpal tunnel syndrome were randomly assigned to each treatment option. A self-administered questionnaire assessed the severity of patients' symptoms and functional status pre- and postoperatively. Treatment costs were estimated from resource use and hospital financial data.**
***Results*: Minimally invasive carpal tunnel decompression is marginally more effective than open surgery in terms of functional status, but not significantly so. Little improvement in symptom severity was recorded for either intervention. Minimally invasive surgery was found to be significantly more costly than open surgery. The incremental cost effectiveness ratio for functional status was estimated to be £197, such that a one percentage point improvement in functioning costs £197 when using the minimally invasive technique.**
***Conclusions*: Minimally invasive carpal tunnel decompression appears to be more effective but more costly. Initial analysis suggests that the additional expense for such a small improvement in function and no improvement in symptoms would not be regarded as value-for-money, such that minimally invasive carpal tunnel release is unlikely to be considered a cost-effective alternative to the traditional open surgery procedure.**

Key words: Carpal tunnel syndrome – Cost effectiveness – Minimally invasive

Carpal tunnel syndrome (CTS) is the compression of the median nerve as it passes through the carpal tunnel in the wrist. It can cause pain and discomfort in the wrist, hand and fingers. A recent study of the prevalence of CTS in the UK general population found it was a common condition with reported prevalence estimates of 7–16%.[1]

Treatment for CTS can be either be conservative (the use of hand splints and anti-inflammatory drugs) or surgical (conventional open carpal tunnel release, minimally invasive or endoscopic procedures). Currently, there is insufficient evidence regarding the most effective treatment for CTS, comparing both conventional and

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Table 1 Effectiveness, descriptive statistics

		Mean	SD	Minimum	Maximum	*P*-value
Functional status						
Open (n = 88)						
	Pre-operative score	35.69	20.51	0	93.75	
	Postoperative score	21.88	19.65	0	75	
	Difference	13.81	21.68	–43.75	75	
Minimally invasive (n = 91)						
	Pre-operative score	32.50	20.86	0	85	0.36
	Postoperative score	18.30	20.28	0	90.63	0.15
	Difference	14.19	18.53	–25	65.63	0.93
Symptom severity						
Open (n = 88)						
	Pre-operative score	19.52	6.78	2.73	36.36	
	Postoperative score	18.31	16.62	0	68.18	
	Difference	1.21	16.38	–40.91	29.09	
Minimally invasive (n = 91)						
	Pre-operative score	17.70	7.12	1.82	33.64	0.07
	Postoperative score	18.60	16.84	0	61.36	0.93
	Difference	–0.91	15.82	–48.18	31.82	0.30

Mann-Whitney non-parametric tests as non-normal distributions.

surgical treatments and comparing different surgical interventions.[2] In an increasingly cost-conscious health service, there is a need to identify value-for-money and, as such, establish what is the most cost-effective treatment for CTS. This article attempts this with a retrospective analysis of the cost-effectiveness of minimally invasive carpal tunnel decompression versus the traditional open surgery technique.

Patients and Methods

In 1997, a randomised controlled trial was conducted in which 208 hands (194 patients) were randomly assigned to either open or minimally invasive carpal tunnel decompression.[3]

Effectiveness was measured using a self-administered questionnaire, whereby patients recorded the severity of their symptoms and functional status.[4] The questionnaire is specific to CTS and, therefore, is more sensitive that other available self-reporting tools. Each patient scored the functional status and severity of their symptoms in the pre-operative consultation and then in subsequent postoperative consultations (up to 3 postoperative recordings were possible). These scores were then converted to percentages: 0 representing normal functioning or no symptoms, 100 representing severely restricted functioning or very severe symptoms. The final postoperative score (either for the second or third visit) was then compared with the pre-operative score to give an indication of function and symptom improvement, *i.e.* effectiveness, as a result of surgical intervention for CTS.

Direct patient costs, specifically transportation expenses, were calculated using a route planner (to calculate the distance patients would have travelled to get to the clinic)[5] combined with an estimate of gross motoring costs per mile.[6] Multiplying this by the mileage for a round trip provided an estimate of motoring costs.

Indirect patient costs, the value of any opportunities forgone, were also estimated. Opportunities were assumed to be forgone in three instances: (i) time spent at the clinic for consultations and the actual surgery; (ii) time away from work while recovering; and (iii) inconvenience due to a delay in returning to normal activities of daily life. Gender-specific average gross earnings were used to value the opportunity cost of a patient's time spent at the hospital and away from work while recovering.[7,8] Forgone non-work activity and leisure time was valued at £3.34 an hour (updated from a 1994 value using the retail price index).[9]

Hospital or provider costs, were derived from the NHS Trust's financial statements. These were combined with resource use to estimate total expenses incurred by the hospital. All procedures were day-cases and the provider costs were similar to the average cost of carpal tunnel release across all NHS Trusts.[10]

Results

Patients who underwent carpal tunnel decompression in both hands, bilaterally, were excluded from the analysis as their treatment, recovery and outcomes were not considered to be representative. This resulted in a total sample of 181 patients/hands, 89 of whom underwent open surgery and 92 who received minimally invasive surgery.

Table 2 Cost, descriptive statistics

		Mean	SD	Minimum	Maximum	*P*-value
Patient costs						
	Open (*n* = 89)	801.23	749.13	65.23	3522.78	
	Minimally invasive (*n* = 92)	779.30	734.82	66.52	3971.43	0.87
Hospital costs						
	Open (*n* = 89)	861.06	68.01	741.48	1042.98	
	Minimally invasive (*n* = 92)	935.88	60.85	809.98	1102.48	< 0.01
Total costs						
	Open (*n* = 89)	1662.29	748.05	912.43	4432.26	
	Minimally invasive (*n* = 92)	1715.18	749.43	884.50	4947.41	0.46

Mann-Whitney non-parametric tests as non-normal distributions.

Table 1 reports the descriptive statistics for pre- and postoperative functional status and symptom severity. The top part of the table shows that the mean difference between scores, that is the average effectiveness of each intervention with regard to functioning, was 13.81 for the open surgery patients and 14.19 for the minimally invasive patients. Both interventions, therefore, appear to be effective, with an improvement of approximately 14 percentage points in the functioning score. While the minimally invasive procedure reports a marginally higher function effectiveness outcome, the difference in means across the two interventions was not statistically significant.

The bottom half of Table 1 shows that in terms of symptoms both interventions are relatively ineffective. The average difference in pre- and postoperative symptom scores for patients who underwent open surgery was 1.21 percentage points, compared with –0.91 percentage points for patients who received the minimally invasive treatment. While the effectiveness measure for symptoms is marginally lower and negative for the minimally invasive procedure, the difference in effectiveness between interventions is not statistically significant.

Table 2 reports the descriptive statistics for patient, hospital and total costs. Concentrating first on patient costs, the table shows that it is estimated that patients' and their families incur expenses ranging from a minimum of £65.23 to a maximum of £3971.43. The cost for the average patient undergoing carpal tunnel decompression is approximately £800; the average cost for open surgery patients (£801.23) is higher than for those who were treated with the minimally invasive technique (£779.30). The reported *P*-value, however, shows that this difference is not statistically significant.

A comparison of patient and provider costs shows that these are quite similar, but more notably provider costs for each surgical intervention are statistically different. Providing minimally invasive carpal tunnel release is found to be significantly more costly for a hospital than providing the traditional alternative of open surgery, an average of £935.88 compared with an average of £861.06. The minimally invasive technique is also more costly when taking both patient and provider costs into account. The average total cost of the minimally invasive technique is estimated to be £1715.18, while the average total cost of open carpal tunnel release is £1662.29, this difference, however, is not statistically significant.

The estimates of provider costs and total costs are combined with the two outcome measures in cost-effectiveness analyses. The results of these economic evaluations are reported in Table 3. While both the provider (hospital) and societal perspectives are reported, later discussions and analyses focus solely on the evaluation using hospital costs, as these are considered to be more accurate and in a publicly funded health care system like the NHS more relevant for public policy.

The incremental cost-effectiveness ratios (ICERs) for symptom effectiveness show that the minimally invasive technique is always dominated by the open procedure, from both the hospital and societal perspective. The

Table 3 Incremental cost-effectiveness ratio

	Average cost	Average symptom effectiveness	Average function effectiveness	ICER (symptom)	ICER function)
Hospital perspective					
Open	£861.06	1.21	13.81		
Minimally invasive	£935.88	–0.91	14.19	Dominated	£196.79
Societal perspective					
Open	£1662.29	1.21	13.81		
Minimally invasive	£1715.18	–0.91	14.19	Dominated	£139.11

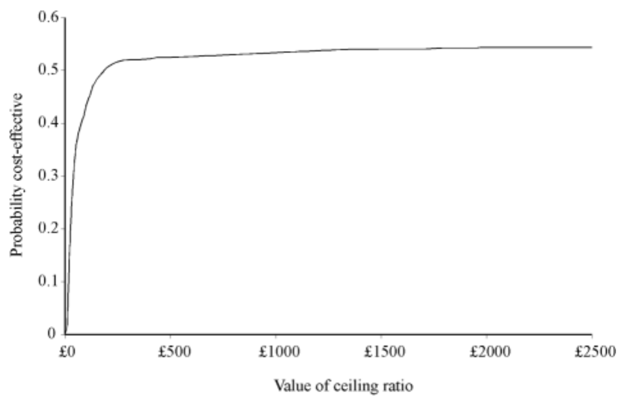

Figure 1 Cost-effectiveness acceptability curve.

minimally invasive technique is more costly and less effective at relieving the symptoms of CTS. When effectiveness is measured using the Levine functional status score, Table 3 shows that while the minimally invasive technique is more costly it is also more effective, generating an ICER of £196.79 and £139.11, from the hospital and societal perspective, respectively. Concentrating on the hospital perspective, this suggests that a one percentage point improvement in functioning (by employing the minimally invasive technique) would cost the hospital £197.

To determine whether this can be regarded as cost-effective, it is necessary to know the providers maximum willingness to pay for such a benefit. To aid in this decision and to control for any uncertainty surrounding the estimated ICER, the data are subjected to bootstrapping and a cost effectiveness acceptability curve generated. This curve is presented in Figure 1 and shows that no matter what the providers ceiling ratio there is never more than a 55% probability that the minimally invasive procedure will be more cost effective than the open procedure.

Discussion

The cost-effectiveness of treatment for CTS is an underdeveloped area. Currently there are only two published economic evaluations, and these compare endoscopic carpal tunnel release with open surgery in the American insurance-driven health care system. They find that endoscopic surgery is more costly but more effective than open surgery.[11,12] Our research comparing a minimally invasive surgical technique with open surgery found somewhat similar results, although the differences in cost and effectiveness were not as pronounced as expected.

It is unclear why the difference in effectiveness across interventions was not as pronounced as expected, but what is more puzzling is the fact that average improvements in symptom severity were minimal for both treatments. There are two possible explanations for this. One is that the patients had not fully recovered, so their symptoms were a consequence of the surgery rather than CTS. The other is that the instrument is not sensitive enough. With regard to the first of these, postoperative symptom severity was recorded up to three times and the last recorded reading (on the second or third visit, although the majority of patients had three postoperative consultations) was used. Given, that the final postoperative visit was 2 years after the surgery, it should not be the case that patients are not fully recovered, so timing should not be an issue. The second suggestion was that the instrument, the Levine score, was not sensitive enough. However, this instrument was developed so it was reproducible, internally consistent and responsible to clinical change,[4] and an independent assessment is also supportive.[13]

One feature of the cost-effectiveness analysis where significant differences were apparent is with the provider costs. These costs were a combination of costs incurred (resources used) at the pre-operative, operative and postoperative stages. Each treatment arm had a standard number of pre- and postoperative consultations, but if there were complications with the surgery or after the fact, additional clinic visits would be required. If the minimally invasive technique resulted in a greater number of complications then this could explain the difference in provider costs. However, there was little difference in the number of reported consultations for complications or in terms of additional physiotherapy. Therefore, the only explanation for the higher cost of providing minimally invasive treatment is the instrumentation. Thus, the two surgical interventions could have similar costs, if the price of the Indiana Tome was reduced (with competition or a monopsonist purchaser like the NHS). If this did happen then it could be that in the future the minimally invasive procedure may be less costly and more effective.

Finally, the incremental cost-effectiveness ratio reported that a one percentage point in improvement in functioning would cost an additional £197. In order to interpret this, it is necessary to examine what exactly a one percentage point improvement means. Recall, that functioning was scored on a scale from one to eight, such that an improvement from 4 to 5 on this scale is actually equal to a 12 percentage point improvement. Therefore, an improvement in the scale from 4 to 5 would cost more than £2300. Given that the estimates presented here show that to treat one patient for carpal tunnel decompression using open surgery costs the hospital appropriately £860, this implies that the use of the minimally invasive technique would mean that the improvement in functioning of one patient would come at the expensive of nearly three other patients who could be treated at a cost of £2580. The opportunity cost is, therefore, quite considerable, which combined with the uncertainty implied by the cost-effectiveness acceptability curve, would suggest the minimally invasive technique is not a cost-effective alternative to traditional open carpal tunnel release.

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