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# Predicting outcomes of conservative treatment for patients with carpal tunnel syndrome: Group- and individual-based rehabilitation

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## Abstract

**Objective:** To identify predicting factors of treatment outcomes of a two stage group-based and then individual-based intervention programme for patients with carpal tunnel syndrome (CTS).

**Methods:** A prospective cohort study where patients diagnosed with CTS were recruited from an out-patient occupational therapy clinic to join the two-stage CTS programme. The Stage-One programme consisted of splinting and educational talks in a group format, while the Stage-Two programme consisted of four weekly individual sessions providing psychosocial support, reinforcing correct ergonomics and mobilization. Baseline assessment on six potential predicting factors and four outcome measures was done for all patients. Patients were re-assessed at the end of the Stage-One and the Stage-Two programme. Analysis was done by binary logistic regression adjusted for baseline covariates.

**Results:** One hundred and sixty-six patients completed the Stage-One programme and 46 patients also completed the Stage-Two programme. Results showed that the Chinese Symptom Severity Scale (SSS) baseline score was the only significant predictor for the Stage-One programme outcomes (AUC for ROC was 0.708) with an optimum cut-off score of 23.5. On the other hand, the Chinese QuickDASH baseline score was the only significant predictor for the Stage-Two programme outcomes (AUC for ROC was 0.801) with an optimum cut-off score of 27.4.

**Conclusions:** The significant predictor for the Stage One Programme was the Chinese SSS baseline score and that for the Stage Two Programme was the Chinese QuickDASH baseline score. The optimum cut-off scores identified may be applied clinically to guide client-centered treatment planning.

## Keywords

Carpal tunnel syndrome, predicting factors, Symptom Severity Scale, QuickDASH, occupational therapy

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## Introduction

Carpal Tunnel Syndrome (CTS) has been reported to affect as high as 5.8% of the population (Arle & Zager, 2000), such as 3.8% in Sweden (Atroshi et al., 1999) and about 5% in the United States (American Academy of Orthopaedic Surgeons Work Group Panel, 2007). The progression of CTS appears to start with symptoms such as numbness or paresthesia and pain in one hand followed by signs such as weakened hand grip, impaired hand function and sensation (Keith et al., 2009; Puchalski et al., 2017). Sleep disturbance and nocturnal awakening are also common in patients with CTS (Patel et al., 2012; Wainner et al.). Another study revealed that individuals with more severe symptoms were likely to develop worse mental health issues resulting in lower quality of life (Jerosch-Herold et al., 2017). Therefore, finding the effective

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interventions are critical to cater for specific needs of this patient population.

According to the recent Cochrane Reviews (O'Connor et al., 2003), there is limited evidence on the effectiveness of non-surgical interventions which have been adopted as the first line treatment for CTS. The common non-surgical interventions include splinting, local corticosteroid injection or oral corticosteroids, therapeutic ultrasound, ergonomic positioning and mobilization exercises. The typical treatment for patients with less severe CTS usually only consists of a simple splinting programme (Middleton & Anakwe, 2014), while more comprehensive programmes use multi-modalities such as a combination of splinting, patient education (Hall et al., 2013; Ollivere et al., 2009), task modification (Burke et al., 2007) and exercises (Akalin et al., 2002). However, the Cochrane Review indicated a tendency for clinicians and researchers to take a wide range of different approaches in selecting interventions to be included in their clinical programmes for CTS. Majority of them incorporated one to three interventions mentioned above without providing clear explanation for the chosen systematic clinical pathways. All CTS programmes utilized individual-based treatment (one therapist attends to one patient at one time). No CTS programme was reported using group-based treatment (i.e. one therapist attends to two or more patients at the same time). However, group-based treatment was recognized to have its merits relating to providing peer support, enhancing motivation and reducing social isolation (Zanca et al., 2013). It had been commonly used in some areas such as treatment of low back pain (Robertson & Harding, 2014) and stroke rehabilitation (Renner et al., 2016) and was found to be equally effective in treatment outcomes. Therefore, this study was aimed: (1) to explore the development of an effective and reliable prediction model to guide a two-stage "group-based" then "individual-based" intervention programme for patients suffering from CTS; and (2) to develop a cost-effective clinical pathway for clinicians to direct the patient flow in a clinic so that CTS patients will receive the necessary interventions as needed.

### *Prediction model for a clinical decision tree*

Literature search identified six studies which reported significant factors predicting outcomes for CTS treatment (Baker & Livengood, 2014; Boyd et al., 2005; Burton et al., 2015; Duckworth et al., 2013; Ollivere et al., 2009; Padua et al., 2001). Six potential variables were included in the prediction model. They were the Symptom Severity Scale (SSS) (Baker & Livengood, 2014; Boyd et al., 2005; Ollivere et al., 2009) the *Quick*DASH (Duckworth et al., 2013), the Functional Status Scale (FSS) (Ollivere et al., 2009), symptom duration (Burton et al., 2015; Padua et al., 2001), positive Phalen's test (Burton et al., 2015; Padua et al., 2001) and age of patients (Padua et al., 2001). Two other significant factors - thenar wasting (Burton et al., 2015) and positive nerve conduction (Duckworth et al., 2013) were not included in the model because they tend to manifest in the later stages of the disorder and therefore not appropriate for patients in this study. Findings of the baseline outcome predictors will be useful for constructing a clinical decision tree to provide clinicians and their patients information on the appropriate course of CTS treatment at admission. Patients can be better informed and prepared regarding whether they will require only a one-stage (a general comprehensive group treatment) or a two-stage intervention (addition of a more intensive one-on-one treatment programme following the Stage-One group treatment programme); as well as the subsequent extent of success that they can expect.

## Methods

### *Subjects*

Patients with diagnosis of CTS were recruited as subjects for the study at an outpatient occupational therapy clinic. The only inclusion criterion was individuals with clinical diagnosis of CTS; referred by family physicians, orthopaedic surgeons, or medical physicians. The exclusion criteria were individuals with: (1) carpal tunnel release completed; (2) serious comorbidities such as malignancy or mental illnesses, multiple sclerosis, stroke, and nerve injury; (3) other symptomatic upper limb neuropathies; and (4) inability to commit to the timeframe of the treatment protocol. All subjects were advised about the purpose of the study. Those who agreed to join the study have provided written informed consent. Ethics approval of the study was obtained from the Human Subjects Ethics Subcommittee (HSEARS20161123001) and the Institutional Review Board (UW 17-173).

### *Two stages of Non-Surgical CTS Treatment Programme*

The CTS Stage-One Group Treatment Programme (called group-based) consisted of two treatment sessions; with four weeks apart. In the first session: (1) a baseline assessment was conducted by an occupational therapist; (2) patients joined a "group" patient-education class to learn information on the disease, ergonomic advice, and a home mobilization programme; and (3) patients were then provided with

custom-fitted hand splint(s) to keep the affected wrist (s) in a neutral position at night and when symptomatic during the day. In the second session: the patients joined another patient-education class to further reinforce the knowledge and skills learned in the first session. Then pre-discharge assessments were conducted, and patients who met the discharge criteria (categorized as "successful treatment") were discharged from the programme.

For patients who did not meet the discharge criteria (categorized as "unsuccessful treatment"), they were then referred to enter the Stage-Two One-on-one Programme (called individual-based). This Stage-Two Programme consisted of four weekly individual sessions. In each session, therapists provided additional psychosocial support, reviewed the home mobilization exercise programme, and "supervised" the patients in performing mobilization exercises and functional use of the affected upper limb(s). Pre-discharge assessments were then conducted in the last session (at the end of four weeks).

### Discharge criteria

There were two discharge criteria, same for both Stage-One and Stage-Two Pogrammes. The first criterion was a score of 3 or above on the Global Assessment of Outcome (GAO) (Jerosch-Herold et al., 2014). The patient was to rate the effect of the treatments they received in the programme with "1" indicating "worse" and "5" indicating "completely cured." Self-reported outcomes have been reported to be useful for patients and clinicians to make better treatment decisions (Black, 2013). The second criterion was "absence of nocturnal awakening in the past week," as sleep disturbance has been shown to greatly impact the sleep and quality of life of CTS patients (Patel et al., 2012).

### Assessments and measures

There were three assessment occasions: at admission, at the end of Stage-One and Stage-Two Programmes. There were four outcome measures: GAO, nocturnal awakening, numeric rating scale (NRS) (0 to 10) (Breivik et al., 2000; Jensen et al., 1999) on numbness and/or paresthesia, and the NRS (0 to 10) on pain. The first two were the same as the discharge criteria for both programmes. There were six predictor variables: (1) Chinese SSS (Fok et al., 2007); (2) Chinese *Quick*DASH (Chan et al., 2019; Institute for Work & Health, 2006); (3) Chinese FSS (Fok et al., 2007); (4) positive Phalen's test; (5) age of patient; and (6) the symptom duration of CTS. Two additional measures were the Patient Health Questionnaire-9 (PHQ-9) (Kroenke et al., 2001) on severity of depressive mood and Job Content Questionnaire I (Karasek et al., 1998) on psychosocial aspects of work (for workers only) for the control of possible confounding factors related to the psychosocial status of patients.

### Data analysis

Between-group differences (successful versus unsuccessful) were tested with t-tests, chi-squared tests, Mann-Whitney U tests, or continuity correction tests based on the nature and distributions of the data. Linear mixed-effects models were used to test for significant changes in the outcome measures before and after the Stage-One and Stage-Two Programmes. Construction of prediction models of treatment outcomes began with testing the correlations among the six predictor variables using Spearman's rank correlation coefficient. Predictor variables with high associations (Spearman $r \geq 0.7$) (Hinkle et al., 2003) were identified and tested for potential collinearity before being entered into the model. A Hosmer-Lemeshow goodness-of-fit test was used to assess the internal validity of multiple regression models. The optimal cutoff score for each significant predictor was computed based on the method described by Ruopp et al. (2008) for maximizing the Youden index (sensitivity + specificity − 1). All statistical analyses were performed using SPSS software (version 24.0), and the statistical significance was set at 0.05.

### Hypotheses

It was hypothesized that the scores of the SSS and *Quick*DASH would be the major predictors of treatment outcomes for patients receiving non-surgical CTS interventions. It was because SSS which measures symptoms severity matches with the treatment contents of the Stage-One Programme and was reported in three prospective studies as a significant predictor. *Quick*DASH which measures symptoms, hand function and daily living performance matches with the treatment contents of the Stage-Two Programme and was reported in one prospective study as a significant predictor. It was further hypothesized that the scores of the SSS and *Quick*DASH would be dissociable within a two-stage programme for CTS since they have different test contents.

## Results

A total of 199 outpatients diagnosed with CTS were recruited. Among them, 166 patients (83%) met the inclusion criteria and were admitted into the intervention protocol (Figure 1). Demographic characteristics and medical information are summarized in Table 1. All patients completed the Stage-One Programme.

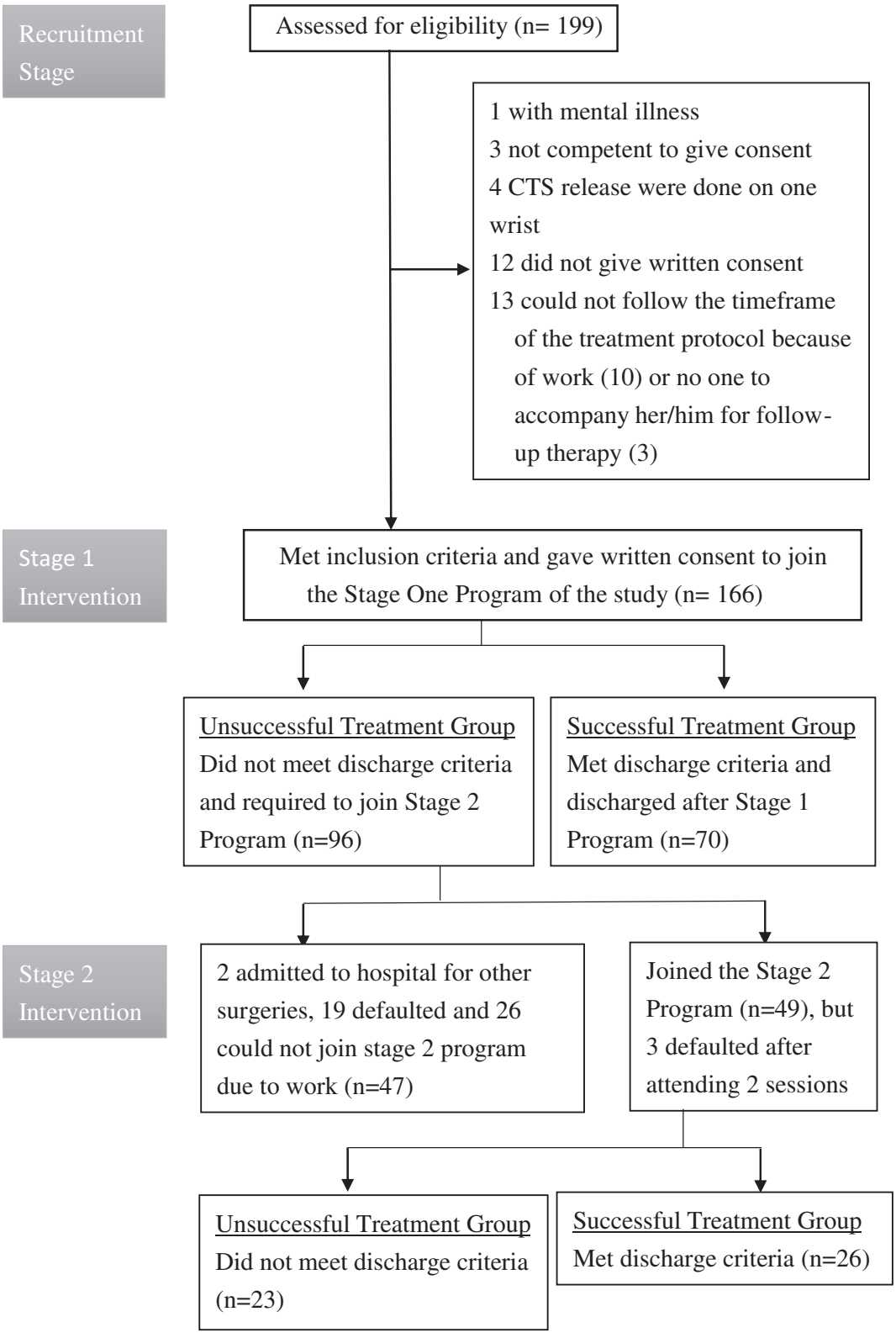


**Figure 1.** Flow of subjects through the study process.

**Table 1.** Demographics of 166 patients admitted into the study.

| | Gender | | Single or bilateral hand involvement | | Work status | |
|---|---|---|---|---|---|---|
| Mean age (years) | Female | Male | Single hand | Both hands | Workers | Non-workers |
| 60.7 (SD = 10.2) | 129 (77.7%) | 37 (22.3%) | 85 (51.2%) | 81 (48.8%) | 75 (45.2%) | 91 (54.8%) |

After one month, 70 patients (42% out of 166) were discharged, as they met the discharge criteria set for the programme. The other 96 patients who did not meet the discharge criteria were invited to enter the Stage-Two Programme. Only 49 patients commenced the four-week programme, and 3 patients defaulted after attending two sessions. Among the 49 patients, 26 patients met the Stage Two discharge criteria, whereas the other 23 patients did not meet the criteria.

### *Stage-One group-based programme*

Significant differences in baseline characteristics and predictor variables were revealed between the "successful treatment" and the "unsuccessful treatment" groups (Table 2). The "unsuccessful treatment" group had a higher female to male ratio [$X^2(1) = 7.80$, $p = 0.005$], higher bilateral to unilateral hand involvement ratio [$X^2(1) = 10.20$, $p = 0.001$], higher level of numbness (NRS scores on numbness) (Mann-Whitney U = 2424, $p = 0.002$ two-tailed), and poorer mental well-being (PHQ-9) (Mann-Whitney U = 2484, $p = 0.004$ two-tailed) than the "successful treatment" group. For the predictor variables, those in the "successful treatment" group showed significantly lower scores on the SSS (Mann Whitney U = 1964, $p < 0.001$ two-tailed), FSS (Mann Whitney U = 2155, $p < 0.001$ two-tailed), and *Quick*DASH (Mann Whitney U = 2125, $p < 0.001$ two-tailed), shorter symptom duration (Mann Whitney U = 2632, $p = 0.017$ two-tailed), and lower ratio of positive Phalen's test [$X^2(1) = 3.87$, $p = 0.049$] than those in the "unsuccessful treatment" group. After completing the Stage-One Programme, patients in the "successful treatment" group showed lower NRS scores on numbness than those in the "unsuccessful treatment" group, suggesting less numbness (Mann-Whitney U = 2424, $p = 0.002$ two-tailed), as well as lower scores on the PHQ-9, suggesting better mental health (Mann Whitney U = 2484, $p = 0.004$ two-tailed) (Tables 3 and 4).

### *Stage-Two individual-based programme*

At baseline, the only significant difference was found in work status; patients in the "successful treatment" group had a higher worker to non-worker ratio than the "unsuccessful treatment" group [$X^2(1) = 0.38$, $p = 0.048$] (Table 2). For the predictor variables, the "successful treatment" group showed significantly lower scores on the FSS (Mann Whitney U = 189, $p = 0.026$ two-tailed) and the Chinese *Quick*DASH (Mann Whitney U = 119, $p < 0.001$ two-tailed), and were younger (t = 2.350, $p = 0.023$) than the "unsuccessful treatment" group. Similar to the Stage-One Programme, the "successful treatment" group continued to have relatively better mental well-being than the "unsuccessful treatment" group, reflected in the scores on the PHQ-9 (Mann-Whitney U = 151, $p = 0.003$ two-tailed) (Tables 3 and 4).

### *Baseline prediction model for treatment outcomes*

Significant correlations were revealed among three predictor variables at the baseline. They were *Quick*DASH and the FSS (r = 0.841, $p < 0.001$), *Quick*DASH and the SSS (r = 0.707, $p < 0.001$), and the SSS and FSS (r = 0.677, $p < 0.001$). No significant correlations were found between the data obtained from Job Content Questionnaire on psychological job demand or job strain ratios and the treatment outcomes.

For the Stage-One Programme, the prediction model showed satisfactory data-to-model fit ($\chi^2$ statistic = 6.74, df = 8, and $p = 0.565$). The Nagelkerke $R^2$ of the model was 0.25; the Chinese baseline SSS score (OR 1.08, $p = 0.027$, 95% CI 1.01–1.15) was the only significant factor predicting "successful" versus "unsuccessful" treatment outcomes. The significant covariate in the model was unilateral or bilateral hand involvement (OR 0.43, $p = 0.021$, 95% CI 0.21–0.88). The Positive Predictive Value (PPV) and Negative Predictive Value (NPV) are 60.9% and 70.0% respectively. Correct classification of patients' memberships was 70.0% (AUC for ROC = 0.708) (Figure 2). The optimal cutoff score set for the baseline SSS was 23.5, yielding a sensitivity of 64.3% and a specificity of 78.1%.

For the Stage-Two Programme, the prediction model showed satisfactory data-to-model fit ($\chi^2$ statistic = 2.77, df = 8, and $p = 0.948$). The Nagelkerke $R^2$ of this model was 0.573 with the Chinese *Quick*DASH (OR 1.17, $p = 0.018$, 95% CI 1.03–1.33) as the only significant predictor of patients' treatment outcomes. The PPV and NPV are 88.5% and 69.6%

**Table 2.** Baseline characteristics between subjects of the successful treatment groups and the unsuccessful treatment groups at the Stage-One and the Stage-Two Programmes.

| | Stage-One Programme | | | Stage-Two Programme | | |
|---|---|---|---|---|---|---|
| Items | Successful treatment group ($n = 70$) | Unsuccessful treatment group ($n = 96$) | $p$ value | Successful treatment group ($n = 26$) | Unsuccessful treatment group ($n = 23$) | $p$ value |
| Gender (male/female) | 23/47 | 14/82 | **0.005** | 4/22 | 5/18 | 0.839 |
| Unilateral/Bilateral hand | 46/24 | 39/57 | **0.001** | 8/18 | 9/14 | 0.539 |
| Worker/Non worker | 31/39 | 44/52 | 0.843 | 14/12 | 6/17 | **0.048** |
| Thenar atrophy (yes/no) | 5/65 | 9/87 | 0.609 | 2/24 | 4/19 | 0.550 |
| Mean NRS pain (SD) | 2.49 (3.12) | 2.92 (3.02) | 0.307 | 3.23 (2.92) | 4.26 (3.53) | 0.335 |
| Mean NRS numbness (SD) | 5.17 (2.44) | 6.34 (2.03) | **0.002** | 6.38 (1.47) | 6.91 (2.09) | 0.321 |
| PHQ-9 (Mean(SD)) | 4.14 (5.23) | 6.20 (5.63) | **0.004** | 4.27 (3.38) | 9.48 (6.28) | **0.003** |
| Mean age (SD) | 61.41 (9.52) | 60.25 (10.63) | 0.468 | 58.38 (9.13) | 64.83 (10.10) | **0.023** |
| Symptom duration (SD) | 19.16 (35.98) | 31.85 (56.10) | **0.017** | 19.00 (23.69) | 36.91 (90.53) | 0.340 |
| Mean SSS score (SD) | 23.26 (8.31) | 28.42 (7.42) | **0.000** | 27.35 (6.47) | 30.52 (8.04) | 0.202 |
| Mean FSS score (SD) | 12.62 (6.21) | 15.11 (5.46) | **0.000** | 14.58 (4.02) | 18.35 (5.87) | **0.026** |
| Mean *Quick*DASH score (SD) | 21.43 (18.34) | 32.05 (17.99) | **0.000** | 27.50 (13.04) | 45.25 (17.33) | **0.000** |
| Phalen's test $\leq$30 s | 34/35 | 62/34 | **0.049** | 18/8 | 16/7 | 0.980 |

$p \leq 0.05$.

**Table 3.** Changes in NRS scores on numbness as an outcome of CTS patients in the Stage-One ($n = 166$) and Stage-Two ($n = 49$) Programmes.

| Parameters | Estimates | SD | *df* | *t* values | *p* values | 95% CI (lower, upper) |
|---|---|---|---|---|---|---|
| Intercept | 3.391 | 1.490 | 118.38 | 2.28 | 0.025 | (0.441, 6.341) |
| Time = 1 | 1.934 | 0.382 | 82.05 | 5.06 | <0.01 | (1.174, 2.694) |
| Time = 2 | 0.734 | 0.367 | 77.44 | 2.00 | 0.049 | (0.003, 1.466) |

Time = 1 is for Stage-One Programme; Time = 2 is for Stage-Two Programme. Significant covariates: unilateral or bilateral hand involvement ($p = 0.024$, 95% CI −0.414 to −0.102) and baseline scores on PHQ-9 ($p < 0.000$, 95% CI 0.055 to 0.172).

**Table 4.** Changes in NRS scores on pain as an outcome of CTS patients in the Stage-One ($n = 166$) and Stage-Two ($n = 49$) Programmes.

| Parameters | Estimates | SD | *df* | *t* values | *p* values | 95% CI(lower, upper) |
|---|---|---|---|---|---|---|
| Intercept | 4.461 | 2.202 | 113.19 | 2.03 | 0.045 | (0.100, 8.826) |
| Time = 1 | 1.328 | 0.583 | 77.77 | 2.28 | 0.026 | (0.167, 2.490) |
| Time = 2 | 0.942 | 0.506 | 79.57 | 1.86 | 0.067 | (−0.066, 1.949) |

Time = 1 is for Stage-One Programme; Time = 2 is for Stage-Two Programme. Significant covariates: baseline scores on PHQ-9 ($p < 0.000$, 95% CI 0.151 to 0.323) and age ($p = 0.017$, 95% CI −0.105 to −0.010).

respectively. Correct classification of patients' memberships was 80% (AUC for ROC = 0.801) (Figure 3). The optimal cutoff score set for the baseline Chinese *Quick*DASH was 27.4, yielding a sensitivity of 57.7% and a specificity of 91.3%. To test the robustness of the baseline Chinese *Quick*DASH, the multiple regression was re-run by entering the post-Stage-One Programme *Quick*DASH data instead of the baseline *Quick*DASH scores. The prediction model was significant; the AUC for ROC curve was 0.730, and the 35.15 cutoff score yielded a sensitivity of 76.9% and a specificity of 65.2%. The results showed that the baseline Chinese *Quick*DASH score was a stronger predictor than the post-treatment QuickDASH scores for the Stage-Two Programme.

## Discussion

Among the six baseline predictors, only SSS and *QuickDASH* were included in the regression models for the Two-Stage CTS Programme. The baseline SSS score was the only significant variable predicting

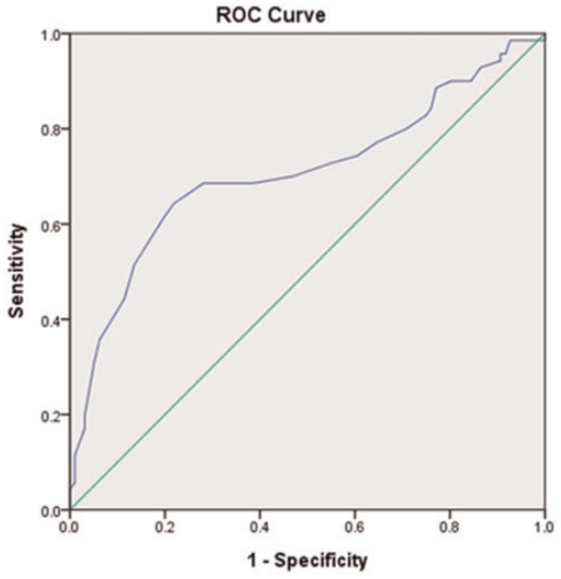


**Figure 2.** ROC curve: predicting the outcome of the successful and the unsuccessful treatment groups after the Stage-One intervention using baseline scores on SSS as the predicting factor. (AUC = 0.708).

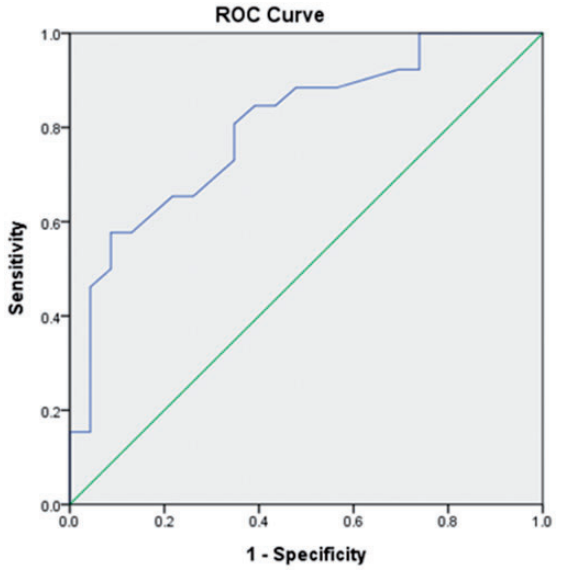


**Figure 3.** ROC curve: predicting the outcome of the successful and the unsuccessful treatment groups after the Stage-Two intervention using the baseline scores on QuickDASH as the predicting factor (AUC = 0.801).

outcomes for the Stage-One group-based Programme. In contrast, the baseline *QuickDASH* was the significant predictor for the Stage-Two individual-based Programme. The dissociation between the SSS and *QuickDASH* in predicting treatment outcomes in two different stages is perhaps due to the notion that the two measures have rather different test constructs; SSS is about symptoms severity whereas *QuickDASH* is more about functional status. These results may also reflect the possible discrepancies between the priority needs of the CTS patients in the Stage-One and Stage-Two Programmes; patients in Stage-One focused on need for symptoms reduction whereas patients in Stage-Two focused on need for improving hand functions.

About 80% of the test contents of the SSS measure CTS-related symptoms. The original purpose of the instrument was to capture patients' responses to treatment for relieving CTS symptoms (Levine et al., 1993). In the Stage-One Programme, the provision of hand splints, learning home stretching exercises and ergonomic strategies in performing daily activities were intended to minimize the symptoms of CTS. The congruent match between the test construct and the content of the Stage-One Programme is likely to account for the SSS being identified as the only significant baseline predictor for the treatment outcomes. The findings of this study concur with results from several previous studies (Baker & Livengood, 2014; Boyd et al., 2005; Ollivere et al., 2009) indicating that lower SSS scores predicted positive (more successful) outcomes of CTS interventions. Treatment modalities found in these studies include 12-week splinting programmes, resting night splints, tendon gliding exercises, and patient education sessions. The "optimal" cutoff score of the baseline SSS scores revealed in this study was 23.5 and it is 4 points lower than the 27.5 reported by Ollivere et al. (2009). The sensitivity and specificity of SSS score cutoff reported by Ollivere et al. (2009) were 67% and 89% respectively, whereas those for this study were 64.3% and 78.1%. The discrepancy might be due to the differences in the population cohorts used in these two studies, as well as the difference in treatment duration and interventions provided. More patients in this study sustained mild symptoms compared to the study by Ollivere et al. (2009). Treatment duration in the present study lasted only one month before re-assessment, while it was three months in Ollivere et al.'s study. Lastly, patients in Ollivere et al.'s study reported to have received local steroid injections, whereas the current study did not. The high specificity value revealed for baseline SSS score would deem to be more important than a high sensitivity value as it can inform clinicians which patients will have less probable positive outcomes from the Stage-One Programme to be immediately triaged to join the Stage-Two Programme for attaining better treatment outcomes.

The Chinese *Quick*DASH questionnaire consists of a disability and symptom scale and an optional work, sport, and instrument-playing scale. This study did not use the optional scale, as not all patients were workers nor sports players. Compared to the SSS, the

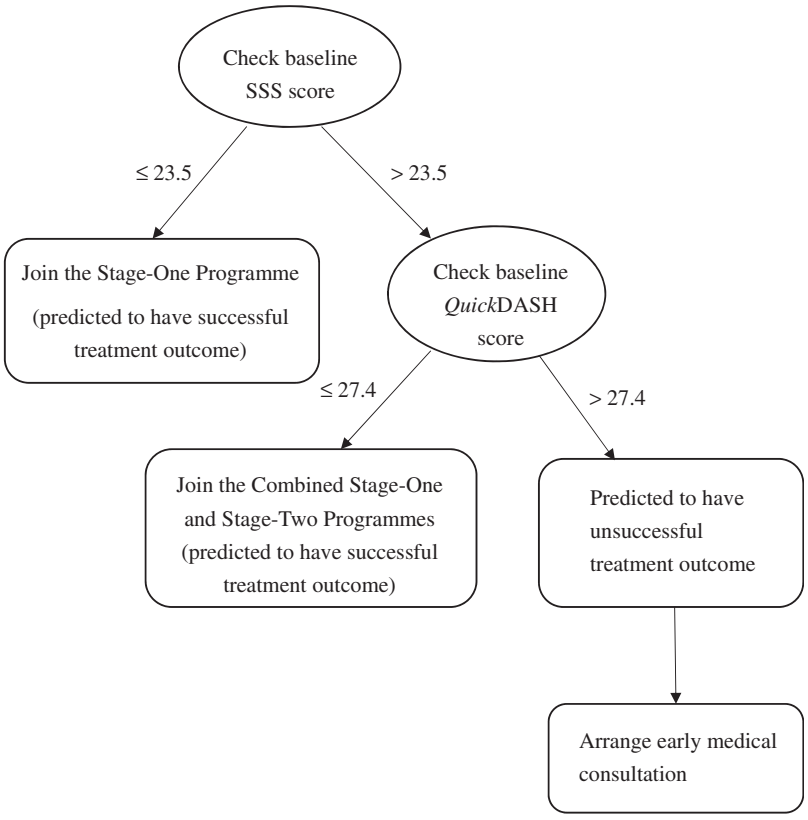


**Figure 4.** Clinical decision tree.

*Quick*DASH questionnaire places more emphasis on hand function and daily living performance. In the course of progression of CTS, weakened hand grip and impaired hand function generally appear after the presentation of symptoms (Puchalski et al., 2017). For the current study, patients who did not meet the discharge criteria set in the Stage-One Programme had significantly higher baseline scores in numbness, SSS, FSS, and *Quick*DASH than those who have achieved the discharge criteria. These higher scores indicated that these patients had poorer hand function and more severe CTS-related symptoms. As the primary focus of SSS is on measuring symptoms, it might not be sensitive enough (compared to *Quick*DASH) to pick up the functional deficits of the hand. Hence, the SSS by itself cannot indicate or predict the patients' need for both Stage-One and Stage-Two Programmes. In fact, the contents of *Quick*DASH are more consistent with the interventions provided in the Stage-Two Programme – hand function training and symptom relief. Therefore, our findings are consistent with reports from Duckworth et al. (2013) that the *Quick*DASH was found to be a significant predictor of one-year outcomes for surgical or non-surgical interventions. Sensitivity and specificity of the baseline *Quick*DASH score cutoff were 57.7% and 91.3% respectively. The high specificity value of 91.3% and high PPV value (88.5%) are new findings for *Quick*DASH. It is meant to identify specific patients who have less probable positive outcomes at baseline to benefit from completing the Stage-Two Programme. Clinicians can base on the baseline *Quick*DASH score cutoff for making decision on arranging early medical appointments for the identified patients seeking advice on alternative treatments to the two Programmes.

Results from the present study have shown 42% of the patients who completed the Stage-One Programme were successfully discharged at the end of the programme. This success rate is comparable to two other studies. One study used splinting for 12 weeks (43%) (Boyd et al., 2005), while the other used splinting for at least six weeks (42%) (Gerritsen et al., 2002). It is noteworthy that in the study by Gerritsen et al. (2002), an 18-month follow-up yielded an increased success rate of 75%. Therefore, it is plausible that had a longer period of follow-up been included in the current study, the success rate of the Stage-One Programme could have been even higher. So, we recommend future research should incorporate a longer follow-up period, if possible 18 or 24 months, to validate the long-term success rates of CTS programmes.

The two-stage conservative programme of this study was specifically designed to initiate treatment in a group format consisting of 8 to 12 patients at Stage-

One. Firstly, group treatment setting facilitated patients having emotional support for one another. This made patients "feel better" as they realized that they were not the sole sufferers from the disease. Secondly, the group format can be more cost-effective and less resource intensive. The search for less costly forms of treatment is an area under intense discussion by the rehabilitation scientific community (Aprile et al., 2011). Thirdly, almost half of the CTS patients were workers, and many could not afford to take leave to attend frequent treatment sessions. Therefore, using the effective predictors to identify an "optimal" treatment programme that matches their needs (either Stage-One or Stage-Two) are crucial for plausible treatment compliance and outcomes.

The two baseline SSS and *Quick*DASH cutoff scores derived from this study are desirable for streamlining conservative treatment protocols for addressing the various needs of CTS patients. A clinical decision-tree based on the two cutoff scores is illustrated in Figure 4. A patient begins by completing the SSS. Those with baseline SSS scores $\leq$23.5 can be prescribed the Stage-One Group Programme, which primarily focuses on symptom relief. Whereas a patient with a baseline SSS score $>$ 23.5 should be administered the *Quick*DASH. With a baseline *Quick*DASH score $\leq$27.4, the patient will be prescribed a combined Stage-One and Stage-Two Programme. The combined programme contains the contents of both Stage-One and Stage-Two Programmes and the total treatment time may be further shortened from the original eight weeks to six weeks as patients requiring intensive treatment can be screened and identified in the baseline assessment. In the case of a baseline *Quick*DASH score $>$ 27.4, the patient will be arranged for further medical advice for treatments other than those from the combined programme, such as surgical interventions. The validity and efficacy of the proposed CTS decision tree need to be further tested in future research. This decision-tree can help clinicians communicate with their patients more effectively; manage patients' expectations about their care plans and the probable treatment outcomes.

### *Study limitations*

There are a few limitations in the present study. Firstly, there was no follow-up with patients who completed the Stage-One and Stage-Two Programmes. Treatment outcomes were determined when patients completed the programmes assigned to them. A longer-term follow-up would have provided useful information on the treatment outcomes and understanding the lasting impacts on the patients. Secondly, as the focus of this study is on testing the usefulness of baseline predictor variables for predicting treatment outcomes, only the "typical" practices of common non-surgical interventions for CTS were adopted. Future research may consider replicating the study by adopting the most current types of interventions for CTS. Furthermore, the number of patients who entered the Stage-Two Programme was relatively small ($n = 49$), which would have biased the results and decreased the power of the analyses. Finally, our results would be limited to CTS patients with similar clinical characteristics to those who participated in this study.

## Conclusions

The findings of the study suggest the importance of matching the content of CTS interventions, as in the Stage-One group-based and Stage-Two individual-based Programmes, with patients' levels of symptom severity and functional impairment. A baseline SSS score can predict the treatment outcome for interventions specific to symptom relief, while a baseline *Quick*DASH score can predict the treatment outcome for interventions specific to functional training and symptom relief. A clinical decision tree based on the optimum cutoff score of the SSS and *Quick*DASH may be useful for guiding treatment plans and managing patients' expectations for the interventions they receive.

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### Ethical approval

Ethical approval was obtained from the Human Subjects Ethics Subcommittee (HSEARS20161123001) of The Hong Kong Polytechnic University, and the Institutional Review Board (UW 17-173) of the Hospital Authority, Hong Kong. Written informed consent was obtained from the patients who participated in the study.

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