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ORIGINAL ARTICLE

A SCREENING TOOL FOR THE EARLY DETECTION OF CARPAL TUNNEL SYNDROME

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Abstract We conducted a preliminary comparative study of 32 carpal tunnel syndrome patients and a control group of 60 individuals matched for age, gender, height, and weight. Our aim is to determine a diagnostic cutoff score for a screening tool we had developed by carefully selecting questions based on the Japanese Society for Surgery of the Hand version of the Carpal Tunnel Syndrome Instrument (CTSI-JSSH). The results were analyzed by using a ROC curve and Youden's index, and the cutoff score was determined to be 7, indicating that subjects scoring ≥ 7 were positive for CTS. We then used this cutoff score to create a 2 × 2 contingency table to calculate the sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, positive predictive value, negative predictive value, and efficiency of the tool. The values obtained were the same as, or higher than, those in previous studies. The screening tool that we developed has the advantages of low cost and low risk; furthermore, it allows for quick self-assessment. Our next step will be to conduct a field survey using a large number of subjects to verify the usefulness of the tool.

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Key words: carpal tunnel syndrome; CTSI; cutoff value; questionnaire; screening tool.

Introduction

Many early detection procedures for carpal tunnel syndrome have been reported, including methods that use hand diagrams,[1, 2)] nerve conduction studies (NCSs),[3, 4)] ultrasonography,[5, 6)] and vibration measurement devices.[7, 8)] However, there are quite a few disadvantages to these methods: identification of the type of the carpal tunnel syndrome by using hand diagrams requires special knowledge, and screening methods that use NCSs, ultrasonography, or vibration measurement devices tend to be costly. Therefore, it is important to develop a screening tool that allows the user to conduct a brief self-assessment without special medical knowledge and at low cost.

The Carpal Tunnel Syndrome Instrument (hereinafter referred to as CTSI)[9)] is an outcome measure used globally to determine the effects of treatment for carpal tunnel syndrome. We have been working to develop a new screening tool for early detection of the carpal tunnel syndrome based on the Japanese Society for Surgery of the Hand (JSSH) version of the CTSI (hereinafter referred to as CTSI-JSSH)[10)].

Our aim was to create a new screening tool based on our research results and to use the tool in a preliminary study to identify a cutoff score for use as a determinant criterion.

Method of Study

1. Creation of the screening tool

On the basis of the results of our previous studies[11-14)] we developed a new screening tool for carpal tunnel syndrome. The screening tool is a questionnaire consisting of the following

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Table 1 Questionnaire

The following questions refer to your symptoms over a typical 24-hour period during the past 2 weeks (circle one answer to each question).

1. Do you have numbness in your hand?
   1: No
   2: I have mild numbness.
   3: I have moderate numbness.
   4: I have severe numbness
   5: I have very severe numbness.
2. How severe is the numbness or tingling at night?
   1: I have no numbness or tingling at night.
   2: Mild
   3: Moderate
   4: Severe
   5: very severe
3. How often did hand numbness or tingling wake you up during a typical night during the past 2 weeks?
   1: Never
   2: Once
   3: Two or three times
   4: Four or five times
   5: More than five times
4. Buttoning of clothes
   1: No difficulty
   2: Mild difficulty
   3: Moderate difficulty
   4: Severe difficulty
   5: Cannot do it at all because of my hand symptoms
5. Taking the cap off a bottle
   1: No difficulty
   2: Mild difficulty
   3: Moderate difficulty
   4: Severe difficulty
   5: Cannot do it at all because of my hand symptoms

5 items: 1 item for the presence/absence of symptoms; 1 item for the presence/absence of night pain; 1 item for night pain causing nocturnal awakening; and 2 items for functional impairment (Table 1). Each item is rated on an ordinal scale from 1 to 5 in the same manner as in the rating system of the CTSI-JSSH. The total score ranges from 5 to 25, with the lowest score indicating absence of subjective symptoms and functional impairment. An increase in the score indicates an increase in the degree of subjective symptoms. Because the questionnaire contains only a small number of question items, individuals can complete it within 3 min.

2. Preliminary study to identify a cutoff score

1) Study subjects

The preliminary study was conducted in patients who, on the basis of subjective symptoms, provocation testing, and an NCS, had been comprehensively diagnosed as having carpal tunnel syndrome by hand surgery specialists at the time of their visit to Hirosaki Memorial Hospital. We also used a control group of individuals matched for age, gender, height, and weight. The preliminary study period was from November 2012 to March 2014. Informed consent to participate in the research was obtained from subjects in the patient and control groups before the study. Subjects with a history of numbness in the upper limb or diseases causing motor disturbance were

Table 2 Comparison of baseline characteristics between the patient and control groups

	CTS* (n = 32)		Controls (n = 60)		95% confidence interval of the difference		*P* value
					Lower	Upper	
Investigation period	Mar. 2013 – Mar. 2014		Nov. 2012 – Jul. 2014		—		—
Age (mean, SD)	62.8	(SD 12.8)	60.4	(SD 10.5)	−2.49	7.35	0.33
Female n (%)	22	(68.8 %)	44	(73.3 %)	—		0.64
Bilateral CTS* n (%)	20	(62.5 %)	—		—		—
Mean height (cm) (mean, SD)	157.9	(SD 10.7)	158.9	(SD 9.0)	−5.12	3.23	0.65
Weight (kg) (mean, SD)	57.7	(SD 10.9)	57.1	(SD 9.5)	−3.93	5.03	0.81
BMI** (mean, SD)	22.4	(SD 2.8)	22.9	(SD 2.9)	−0.81	1.72	0.48
Questionnaire score (mean, SD)	12.6	(SD 3.8)	5.5	(SD 1.0)	—		$P < 0.01$

* CTS: Carpal tunnel syndrome ** BMI: Body mass index

excluded from the control group. The study was conducted with the approval of the Hirosaki University Graduate School of Medicine Ethics Committee.

2) Method of study

Using a questionnaire created as a screening tool, we conducted a preliminary study on the patient and control groups to establish a determinant criterion for the main study. The outline of the study was explained in written or oral form to subjects in the patient group at the time of their visit to the hospital, and the subjects were asked to directly fill in the questionnaire. Basic information on individual subjects was also gathered. The survey of subjects in the control group was conducted by using a combination of interviews and mail-outs. Subjects were given an outline of the study in written or oral form and were asked to fill in the questionnaire, which was handed in directly or mailed to the researcher. The cutoff score for identifying patients with carpal tunnel syndrome was determined from a statistical analysis using the scores for each item and the total score.

3) Statistical analysis

In the first step of the statistical analysis, we compared baseline characteristics between the patient group and the control group to search for differences. A 2-sample t-test was used to analyze differences in age, height, weight, and BMI. A chi-squared test for goodness of fit was used to analyze the percentage of women. Differences in scores in the questionnaire were examined by using the Mann-Whitney *U* test. Next, we used an ROC curve to determine a cutoff score using Youden's index. We then created a 2 × 2 contingency table to calculate the sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, positive predictive value, negative predictive value, and efficiency of the tool. Statistical analyses were performed with IBM SPSS Statistics Version 20J for Windows at the 5% significance level.

Results

1. Physical characteristics and total questionnaire scores in each group (Table 2)

During the preliminary study period, 32 patients were diagnosed as having carpal tunnel syndrome. In accordance with the Padua classification,[15] patients were placed into the following categories on the basis of the degree of severity of their carpal tunnel syndrome: 1 in minimal, 5 in mild, 3 in moderate, 19 in severe, and 4 in extreme. The control group consisted of 60 subjects in total, drawn from among the staff members of Hirosaki University of Health and Welfare and local residents.

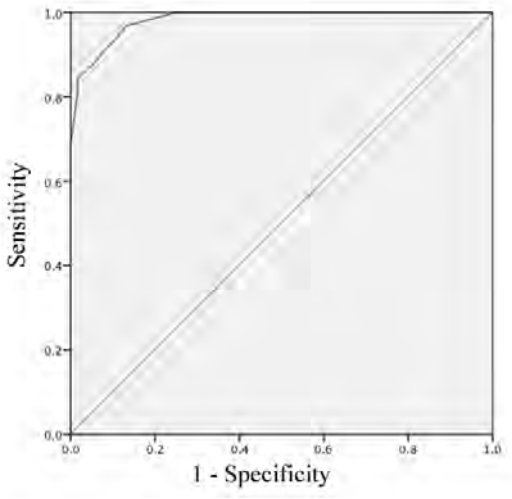

Fig. 1 Results of the ROC curve

Table 3 Cutoff values

Cutoff value	Youden's index*
≥6 points	0.75
≥7 points	0.84
≥8 points	0.83
≥9 points	0.83
≥10 points	0.80

* Sensitivity + Specificity – 1

Table 4 Results of 2-way contingency table analysis

	CTS	Control	Total
Outcome positive	31	8	39
Outcome negative	1	52	53
Total	32	60	92

CTS: Carpal tunnel syndrome

Comparison of the baseline characteristics of the patient and control groups in the preliminary study revealed that the percentages of women in the patient and control groups were 68.8% and 73.3%, respectively, showing a slight difference between the groups. However, in the chi-squared test for goodness of fit, the *P*-value was 0.64, indicating that there was no difference between the groups. No significant differences were observed in height, weight, or BMI between the 2 groups. In contrast, the mean total questionnaire scores for the patient group and control group were 12.6 ± 3.8 and 5.5 ± 1.0, respectively. The value for the patient group was significantly higher ($P < 0.01$) than that for the control group, suggesting that the patient group had stronger subjective symptoms.

2. Determination of the cutoff score

The area under the ROC curve was as high as 0.983 (Figure 1). Youden's index reached its maximum, 0.84, with a cutoff score of 7 (Table 3). From these results, we created a 2 × 2 contingency table with a cutoff score of 7 (Table 4). From the contingency table we obtained the following values: sensitivity, 96.9%; specificity 86.7%; positive likelihood ratio (PLR) 7.27; negative likelihood ratio (NLR), 0.04; positive predictive value (PPV) 79.5%; negative predictive value (NPV) 98.1%; and efficiency 90.2%. Table 5 lists the values and their 95% confidence intervals.

Discussion

Many studies have reported various screening tools for carpal tunnel syndrome, including hand diagrams, NCSs, and ultrasonography.[1-8] Methods that use diagrams have the advantages of low cost, simplicity, and speediness. Although diagrams can be used with large groups of people, special knowledge is required for identification. NCSs and ultrasonography are widely used; such methods that use equipment have high sensitivity and specificity and are of high diagnostic value; however, they are hindered by disadvantages such as high cost, long testing times, and the need for high-level techniques and knowledge for equipment operation and diagnosis (Table 6). We have been developing a new screening tool to overcome these problems.[12-14]

The primary focus of our development of the

Table 5 Comparison of stratification of likelihood ratios in each group

	Value	95% confidence interval	
		Lower	Upper
Sensitivity	0.969	0.87	0.994
Specificity	0.867	0.814	0.88
Positive likelihood ratio	7.266	4.683	8.309
Negative likelihood ratio	0.036	0.006	0.159
PPV*	0.795	0.714	0.816
NPV**	0.981	0.922	0.997
efficiency***	0.902	0.834	0.92

*Positive predictive value; **Negative predictive value
***Diseased persons with a positive test and healthy persons with a negative test / all tested

Table 6 Advantages and disadvantages of the screening tool

	Advantages	Disadvantages
Diagram	● Can be used with large population groups ● Low cost	● Expertise needed
NCS*	● High diagnostic value	● High cost ● Medical equipment needed ● Long testing time
Ultrasound	● High diagnostic value	● High cost ● Medical equipment needed ● Long testing time
Questionnaire	● Can be used with large population groups ● Low cost ● Can be used for self-checks	● Is diagnostic precision low?

*Nerve conduction study

screening tool is to motivate people who have mild subjective symptoms and are debating whether or not to go to a doctor to get medical advice. We therefore considered that a low cost, questionnaire-based screening tool that allowed for easy self-assessment would be ideal. We decided to use the CTSI-JSSH[10], which is used extensively used in Japan, as a basis for our tool.

The CTSI-JSSH[10] is a questionnaire with a total of 19 items, consisting of 11 items on symptom severity (SS) and 8 items on functional status (FS). To be used effectively as a screening tool, a questionnaire should be designed in such a way that it requires only a short time to answer, thus minimizing the inconvenience to the respondent. To resolve this issue, we performed a statistical analysis to identify factors significantly affecting the CTSI-JSSH scores and thus reduce the number of questions.[11-14] The results revealed that the SS score of the CTSI-JSSH was significantly affected by "numbness" and "night pain" and that the FS score was strongly related to the actions of "buttoning" and "opening and removing a bottle cap". The new questionnaire we have created consists of 5 question items related to these factors.

Determining a cutoff score and the sensitivity and specificity of the screening tool is very important. Our results showed that the sensitivity, specificity, and efficiency with a cutoff score of 7 (i.e. where scores ≥ 7 are positive) all

exceeded 80%, and the area under the ROC curve was as high as 0.983; this demonstrated that the questionnaire was highly efficient. There have been other reports of the sensitivity, specificity, and efficiency of screening tools: Katz et al.,[1] in a study that used diagrams, reported that both the sensitivity and the specificity were ≥ 80% when "probable" or stronger symptoms in a 4-stage rating system were taken as positive. Schuhfried et al.[3] reported that the sensitivity, specificity, and efficiency were all 80% when the difference in antidromic sensory nerve conduction velocity between the median and ulnar nerves of the ring finger was used. From this information, we consider that our tool yielded a sensitivity, specificity, and efficiency that were higher than those reported for earlier screening tools.

Among the most useful benefits of the screening tool that we developed are its low cost and its ability to allow for self-assessment. Because it is in the form of a questionnaire, various types of survey are possible, such as a survey targeting a large number of subjects by mail or an online survey using the Internet. Substantial cost reduction is therefore possible. This screening tool can be used not only by specific regions or medical institutions but also by the general public who have not received medical attention, or by those who undergo workplace-based health checkups. Furthermore, processing the questionnaire requires only simple calculations; respondents have to answer questions on only 5 items concerning symptoms and functions and can do this quickly. This not only reduces the inconvenience to respondents but also allows them to keep track of their hand conditions accurately on the basis of the cutoff point, which in turn should prompt early visits to healthcare providers and early detection and therapy of carpal tunnel syndrome.

Conclusions

We created a new screening tool based on the CTSI-JSSH by carefully selecting the questions, and we conducted a preliminary study on a patient group and a control group to determine a cutoff score. Screening efficiency was highest with a cutoff score of 7. The questionnaire not only has a higher efficiency than those in earlier studies but also has the benefits of low cost and rapid self-assessment of users. We now intend to use the questionnaire and the cutoff score to conduct a large-scale field survey of individuals with no history of medical attention and to thus verify the effectiveness of the questionnaire as a screening tool.

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