Content Analysis of Specialist Interviews During the Design of Cervical Collar Devices for Elderly Patients with Central Cord Syndrome

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Abstract. This study aimed to analyze the design of cervical collar devices for elderly patients with central cord syndrome during physical therapy-based rehabilitation and to summarize related patient needs. To design a cervical collar device that met patient needs, a physician and patients who had worn a cervical collar for more than three months were both interviewed to collect opinions from a professional perspective and from user experience. A qualitative analysis of the content of the interview was then conducted to characterize an optimal cervical collar device for elderly patients with central cord syndrome during rehabilitation. The analytical results showed that cervical collar device development should focus on comfort and fixity.

Keywords: Central cord syndrome · Cervical collar · Content analysis · Participative design · Rehabilitation

1 Introduction

Central cord syndrome (CCS) is the most common traumatic phenomenon. A study by Brodell et al. (2015) found that patient age and complications affected patient mortality. There are many causes for CCS. A study by Aito et al. (2007) found that the causes of injury included traffic accidents (57 %), falling (36 %), and sports (7 %). Generally, treatments for CCS include both surgical and non-surgical treatments, and a cervical collar is required for neck fixation in either case. Burl et al. (1992) tested the walking balance of healthy young women wearing a protective cervical collar, and the results showed that a cervical collar did not affect the walking balance of healthy young woman. However, according to a study by Waters et al. (1994), most patients with CCS need an assisting device to help them walk safely, and training for walking and gait should be provided by a physical therapist during the rehabilitation of CCS patients to improve their torso balance and stability (Michelle 2015). A study by Miller et al., (2013) found that, when a test subject wore a rigid cervical collar and performed

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activities such as putting on socks, putting on shoes, reading, eating, walking upstairs, and walking downstairs, the restriction to the neck due to a rigid collar was similar to that due to a soft collar. Theoretically, the restriction of neck motion by a rigid cervical collar should be greater than that of a soft cervical collar, but the results of their study showed a similar restriction for both the rigid collar and the soft collar. In 2013, Evans et al. (2013) compared the fixity of elongated flexion, lateral bending and rotation for five types of cervical collars, including the Aspen®, Philadelphia®, Vista®, Miami J®, and new Miami J® collars, and their experimental data showed that the Vista® collar was superior to the other collars in various tests. In that study, researchers measured the range of neck motion when a test subject was wearing a cervical collar. They found that, in lateral bending, the neck fixity of the Vista® cervical collar was not superior. According to a study by Karason et al. (2014) the Miami J® collar is appropriate for emergency and long-term treatment, while the Vista® is appropriate for long-term treatment. Thus, when a CCS patient needs to wear a cervical collar while simultaneously performing rehabilitation activities, the utility of commercially available collar devices is questionable. If a collar device cannot provide sufficient utility, it may cause patients to be inconvenienced or to have a bad experience.

Thus, the present study aimed to develop a collar device that is suitable for elderly patients with CCS during rehabilitation and that assists with rehabilitation and slowly trains the basic functions of the neck. To assess whether a prototype collar device can meet the needs of elderly patients with CCS during rehabilitation, this study used a semi-structured questionnaire to collect the professional opinion of a physician and the opinions of experienced users who had been wearing the cervical collar device for more than three months. Language analysis was conducted for the obtained interview contents to identify the most-desired features of the cervical collar. This study is divided into four sections. The first section is the research background and motivation, the second section is the design of the cervical collar, the third section is the content analysis of the interview and discussion, and the last section is the conclusion.

2 Design of the Cervical Collar Device

In this study, patient needs and questions about the cervical collar device were first collected from patients using interviews. A prototype of the cervical collar was then designed based on user needs in concert with a literature review and participative design. The professional opinion of a physician and the opinions of experienced users were integrated into the prototype design of the cervical collar, which was in line with the biomechanical principles of a cervical brace. The supporting sites were on the upper chest to the jaw and occipital. The supports at these sites enhanced the stability of the cervical collar. The cervical collar must remain at the center of the head while avoiding concentrated pressure on the skin at any of the contacting sites; the contact pressure should be evenly distributed. In a study by Miller et al. (2010a, b), a Vista® collar that allowed six adjustable heights with 1.5-cm increments was used, and it was found that the height of the collar device was related to its fixity for the neck. The test for the Vista® collar was to adjust the height using the upper limb knob on the front panel of the collar so that it could fit users of different heights. The height-adjustment function

was not available with the Miami J® collar, which instead offered different sizes to fit users with different neck heights and sizes. In the future, our work will attempt to implement a design with different heights based on the characteristics of the rack structure and the original hexagonal mesh at different densities. The changes in height will result in different levels of fixity for users in different situations, recapitulating the difference between the Vista® collar and the Miami J® collar. A hexagonal mesh was used because of its good mechanical and geometrical properties, as a hexagonal structure provides a high strength-to-weight ratio (Zhang et al. 2015). CCS may result in upper-limb movement being more difficult than lower-limb movement (McKinley et al. 2007). Therefore, the prototype cervical collar in this study was designed to be fixed from the front to the rear with the assistance of another person. The frame of the prototype collar body is constructed of ABS (acrylonitrile butadiene styrene). An isometric view of the overall appearance of the prototype design is shown in Fig. 1. The rear panel of the prototype collar is shown in Fig. 2. The entire collar device was then assembled with its different parts and structures. The main parts and structures are listed with their functions in Table 1.

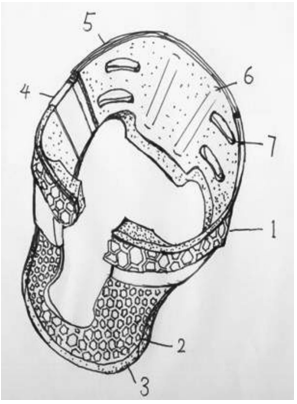

Fig. 1. Isometric view of the overall appearance of the prototype collar design

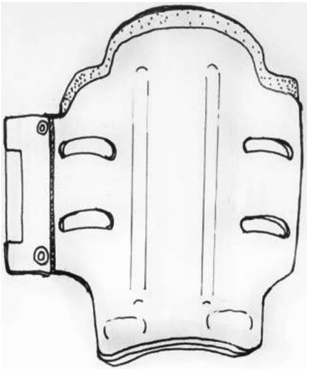

Fig. 2. The rear panel of the prototype collar

Table 1. Nomenclature and functions of different parts of the collar device

No.	Name	Description
1	Main part of the front panel	Constructed of hexagonal mesh and can be assembled with or without the supporting part of the front panel (2).
2	Supporting part of the front panel	Mainly constructed of hexagonal mesh and can be removed from the main part of the front panel (1).
3	Cushions	Used at pressure-bearing sites in the jaw, the rear of the neck, and the thoracic areas to avoid direct skin contact with the hard material of the main part.
4	Buckle	Allows fixation of the device.
5	Main part of the rear panel	Provides protection and fixation for the back of the neck.
6	Booster strip of the rear panel	Located on both sides of the spine to prevent patient lean-back.
7	Air hole	For ventilation.

3 Content Analysis of Interviews and Discussion

To assess whether the prototype collar design met the needs of elderly patients with CCS during their rehabilitation, a semi-structured interview was conducted with one professional rehabilitation physician and two experienced patients. The interview content was then analyzed using linguistic analysis.

3.1 Physician and Patient Interviews

The interview questions were pre-designed. The physician responded according to his expertise, while the patients answered the questions based on their experience using the cervical collar device. Information about the interviewees is shown in Table 2. The researchers recorded each interview verbatim, and the interview content was then analyzed using linguistic analysis.

(1) Physician respondent

The interviewed physician was Doctor Xu Jialin, of the Department of Rehabilitation, Li Shin Hospital, Taiwan. Dr. Xu is a clinical physician with experience in elderly rehabilitation and in applied research on prostheses and assistive devices.

(2) Patient respondents

The interviewed patients had been diagnosed with CCS and had experienced wearing a collar device for more than three months.

Table 2. Information about the interview respondents

Physician			
Name	*Expertise*		*Experience*
Xu Jialin	General rehabilitation, elderly rehabilitation, application of prostheses and other assistive devices		Department of Rehabilitation, Li Shin Hospital
Patients			
Pseudonym	*Situation*	*Collar device*	*Duration of collar use*
Chen Yihan	Long-term occupational upward-looking posture for fruit harvesting, which led to compression on the nerves that caused hand weakness; underwent surgery	Vista®	Approximately six months
Li Xincheng	Long-term occupational posture led to compression on the nerves, causing hand numbness and inflexibility; underwent surgery.	Vista®	Approximately six months

(3) Interview tools

Information for this study was collected in the context of formal interviews. The physician interview consisted of three aspects. The first aspect included questions related to the rehabilitation of elderly patients with CCS; the second aspect included questions related to elderly patients with CCS and their use of an existing collar; and the third aspect included questions related to professional ideas and suggestions for the prototype collar design described in this study. The patient interviews also consisted of three aspects. The first aspect included questions related to problems that were encountered during rehabilitation when wearing the collar; the second aspect included questions related to comments about the collar that was currently being worn; and the third aspect included questions related to patient opinions and suggestions for the prototype collar design described in this study. Consent to photograph and to record audio (and video if needed) during the interview was obtained from the respondents in advance.

(4) Interview content organization and analysis

In this study, the content analysis method was used for evaluation. In this method, content may be obtained from mail, diaries, newspapers, novels, articles, and symbols. Content analysis then seeks to convert the original contents of a file into data. In this study, the recorded audio file of the interview was first converted into a verbatim manuscript, which was then encoded for analysis.

The implementation procedures in this study were as follows: (a) the recorded audio file of the interview was converted into a verbatim manuscript; (b) the text in the manuscript was classified according to the part of speech of each word, as judged by the meaning of each phrase, and the part-of-speech classification included an analysis of word frequency; (c) for all content, numbers, punctuations, and meaningless words were eliminated, while the frequencies of the remaining verbs, nouns and adjectives were calculated, and similar categories were combined to form major categories based on the meaning of the phrases; and (d) in the major categories, the frequency of the text was used to infer the relative importance of each corresponding phrase in the physician and patient interviews, and the exact meaning of each expression was extracted.

Content analysis of the patient interviews allowed us to extract patient impressions of the current commercial products and their expectations for the prototype collar device. Similarly, content analysis of the physician interview allowed us to extract his professional opinions and the key features of the prototype collar design in this study. The suggestions of the physician provided a more specific direction for the prototype collar design and its future application.

3.2 Results of the Interview Analyses

3.2.1 Content Analysis of the Patient Interview

In the patient interview content analysis, the phrase density was 1.12. According to the part-of-speech classification published by the Ministry of Education, the word properties, part of speech, frequency and percentage were sorted (Table 3).

The content analysis results for the patient interviews revealed 34 nouns, 16 adjectives, and 37 verbs. The statistical analysis of the part-of-speech frequency was manually performed. During the statistical process, the error was verbatim-checked against the original manuscript. Finally, 13 phrases that were highly related to the topic of this study

Table 3. Content analysis of the patient interviews: parts of speech

Notional word		Part of speech	Frequency	Percentage
		Noun	34	23
		Adjective	16	11
		Verb	37	25
		Adverb	10	7
		Pronoun	9	6
		Quantifier	2	1
Functional word	**Relative**	**Preposition**	1	1
		Conjunction	6	4
	Modal particle	**Interjection**	1	1
Punctuation		**,**	23	16
Number		**Roman numeral**	8	5

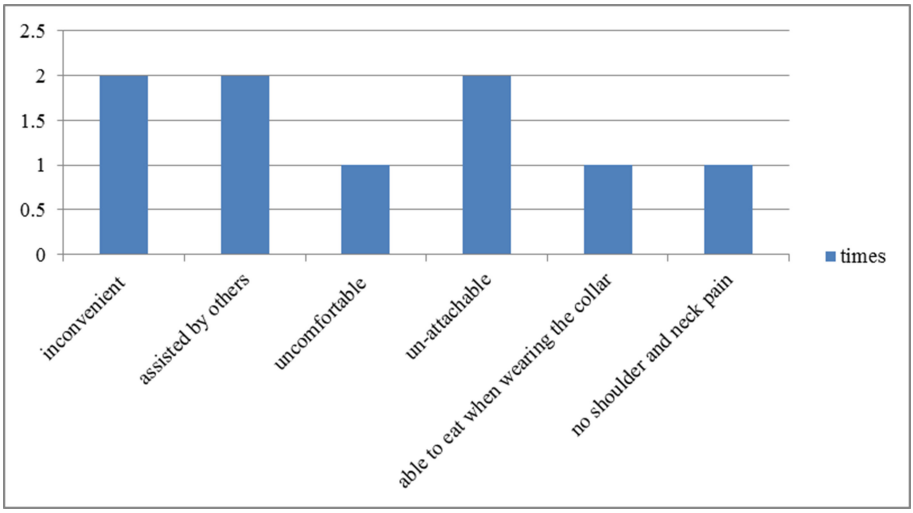

Fig. 3. Results of the content analysis for the patient interview

were selected from the total patient interview content and classified into seven primary categories for frequency analysis. The analytical results are shown in Fig. 3.

The frequently encountered phrases "inconvenient" (2 times), "uncomfortable" (1 time), and "un-attachable" (2 times) were classified as sensations of patients when using the collar and accounted for 71.4 % of the phrases. Meanwhile, "assisted by others" (1 time), "able to eat when wearing the collar" (1 time), and "shoulder and neck pain" (1 time) were classified as needs of the patients while using the collar and accounted for 28.6 % of the phrases. Because the sensations of patients when using the collar accounted for 71.4 % of the phrases, this result implies that sensations are of most concern to the patients, followed by the needs of patients in using the collar device, which accounted for 28.6 % of the phrases.

3.2.2 Content Analysis of the Physician Interview

In the content analysis of the physician interview, the phrase density was 0.62. According to the part-of-speech classification published by the Ministry of Education, the word properties, parts of speech, frequency and percentage were sorted (Table 4).

The content analysis results for the physician interview showed 84 nouns, 64 adjectives, and 69 verbs. The statistical analysis of the part-of-speech frequency was manually performed. During the statistical process, the error was verbatim-checked against the original manuscript. Finally, 371 phrases that were highly related to the topic of this study were selected from the total content of the physician interview, and they were classified into 15 primary categories for frequency analysis. The analytical results are shown in Fig. 4.

The frequent phrases "patients with CCS" (2 times) and "elderly" (3 times) were classified as the objects of collar usage and accounted for 22.7 % of the phrases; "assisted by others" (3 times), "rehabilitation" (2 times), "comfort" (7 times) and "fixity"

Table 4. Content analysis of the physician interview: parts of speech

Notional word		Part of speech	Frequency	Percentage
		Noun	84	23
		Adjective	64	17
		Verb	69	19
		Adverb	15	4
		Pronoun	15	4
		Quantifier	7	2
Functional word	**Relative**	**Preposition**	4	1
		Conjunction	19	5
	Modal particle	**Interjection**	9	2
Punctuation		,	66	18
		.	9	2
Number		**Roman numeral**	8	2
Unclassifiable		**English/Oral argument**	2	1

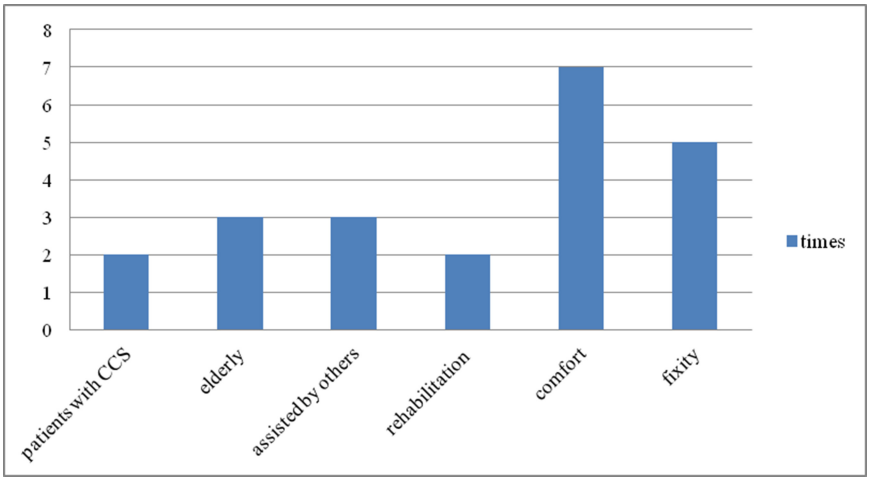

Fig. 4. Phrase frequencies after content analysis of the physician interview

(5 times) were classified as patient needs when using a collar and accounted for 77.3 % of the phrases. As the needs of the patient during collar use accounted for 77.3 % of the total phrases, this is the topic of greatest concern for the physician.

3.3 Discussion

This study, we attempted to develop a prototype collar for elderly patients with CCS during their rehabilitation. Both a professional physician and actual collar users were interviewed. The collar design was based on user needs and was then modified and improved according to the opinions of the physician as a result of the follow-up interview. The results of the physician interview and the patient interviews were discussed. First, content analysis of the patient interviews showed that the interview contents included (1) patient sensations when using the collar and (2) the needs of patients with respect to the collar. The two patients were interviewed indoors during the summer. The patients were both wearing Vista® collars, and their feelings about the collars were mainly that they were hot and oppressive with the chest support, thereby causing discomfort and inconvenience during some activities. Assistance of others was often needed. The collar needs to be taken off for cleaning after long-term use, and it requires occasional adjustment to ensure comfort. Thus, the Velcro fixing strap must be repeatedly pulled on and off; after time, wear may render the strap un-attachable. Next, content analysis was performed for the physician interview. The results of the analysis included (1) the objects of collar usage and (2) the needs of the patients with respect to the collar. For the objects of collar usage, it was clear that the collar designed in the present study is for "patients with CCS" and "elderly" users. The common characteristic of these two groups is that they are unable to flexibly operate their hands. Therefore, the important parts of the collar must be designed to be large and easily operated. The patients' needs with respect to collar use included the "assistance of others", "rehabilitation", "comfort", and "fixity". As the users are not able to flexibly operate their hands, the assistance of others is typically needed to put on the collar. If the important parts of the collar are large and easy to operate, people can easily explain their use to patients at the time of operation, thus reducing difficulties in communication. As the collar is designed for use during patient rehabilitation activities, the physician recommended that the collar should fit the neck as perfectly as possible and that a multi-piece collar will work better. For optimal comfort and fixity, the contact sites of the collar at the jaw, sternum, and occipital regions must be considered. The collar should be fixed at the unmovable sites; the comfort of the collar is mainly judged by whether a patient experiences pain when wearing the collar. Finally, the physician made positive comments about the conceptual collar design proposed by the investigators, but he also reminded the researchers to pay attention to the materials used. Certain materials can be considered to increase the performance of the collar.

In summary, the hexagonal structure concept in the present study is promising. The collar design is expected to combine comfort and fixity, especially for the supporting sites where pressure is applied. In future improvements of the collar, this concept will be further discussed.

4 Conclusion

In this study, a cervical collar device was designed for elderly patients with CCS during physical therapy-based rehabilitation. First, the respective literature relating to collar devices, elderly patient rehabilitation and CCS were reviewed and collected. Based on interviews with actual patients, user needs and usability issues related to cervical collar devices were better understood. Content analysis was performed on the interview content as a reference for the design of the conceptual prototype collar. In this study, in addition to considerations from the user perspective, a professional physician was also interviewed to further discuss potential collar problems from a professional perspective. Thus, the design of the prototype collar can better meet the needs of elderly patients with CCS during rehabilitation, providing a safer and more comfortable user experience. In the future, this study will enhance the collar design with a hexagonal mesh structure to better suit elderly patients.

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