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Use of a Smartphone Medical App Improves Complications and Quality of Life in Patients with Nasopharyngeal Carcinoma Who Underwent Radiotherapy and Chemotherapy

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Funds Collection G

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Background: We explored the intervention effect of a smartphone medical app on complications and quality of life of patients with nasopharyngeal carcinoma who underwent radiotherapy and chemotherapy.

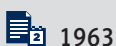
Material/Methods: We divided 132 patients with nasopharyngeal carcinoma who received radiotherapy and chemotherapy for the first time, in accordance with the random number table method, into a control group (67 patients) and an intervention group (65 patients). Patients in control group were discharged with standard care and patients in the intervention group used a smartphone medical app after discharge. Data on adverse effects of radiotherapy and chemotherapy, complications, and quality of life were collected and analyzed.

Results: There was no difference between the complications of radiotherapy and chemotherapy and quality of life between the 2 groups at discharge ($P > 0.05$). The incidence of oral mucositis, xerostomia, mouth-opening difficulties, and nasal congestion in the intervention group was significantly lower than in the control group at 6 months after discharge and quality of life was significantly higher than in the control group ($P < 0.05$).

Conclusions: Reasonable use of this smartphone app can improve the exercise compliance of discharged patients with nasopharyngeal carcinoma who underwent radiotherapy and chemotherapy, reduce the adverse reactions and complications of radiotherapy and chemotherapy, and improve quality of life and satisfaction of patients after discharge.

MeSH Keywords: **Mobile Applications • Nasopharyngeal Neoplasms • Postoperative Complications • Quality of Life**

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Background

Nasopharyngeal carcinoma (NPC) is a malignant tumor that occurs in the nasopharyngeal mucosa epithelium [1,2] and is generally treated with radiation therapy [3,4]. However, the complications and adverse reactions after radiotherapy and chemotherapy cannot be ignored [5], such as oral mucosal lesions, mouth-opening difficulties, xerostomia, hearing loss, and nasal congestion [6,7], but most patients with NPC only receive conventional discharge health education after their radiotherapy and chemotherapy treatment in the hospital. Because of their poor self-management ability, it not only affects the treatment effect, but also seriously affects their quality of life.

A smartphone medical application (app) can play a positive role in the self-management of patients and improve the compliance behavior of patients. In 2011, a survey in the United States showed that 84% of respondents have a smartphone, and that 53% of people with smartphones already use apps in clinical practice. The use of smartphones and apps is prevalent among orthopedic care providers in academic centers [8]. Another survey revealed patient behavior patterns that would be useful in future app development. Being able to record, analyze, seamlessly share, and obtain feedback on the SMBG data using an iPhone/iTouch app might benefit patients [9]. GM Turnermcgrievy reported the potential benefits of mobile monitoring methods during behavioral weight loss trials. Future studies should examine ways to predict which self-monitoring method works best for an individual to increase adherence [10]. However, the current research on the use of mobile medical apps for discharged NPC patients who underwent concurrent radiotherapy and chemotherapy has not been further studied. Therefore, in the present study we used a smartphone medical app as an intervention method for discharged NPC patients who underwent radiotherapy and chemotherapy to share information about NPC disease, such as observation and treatment of complications of radiotherapy and chemotherapy, as well as regular re-examination, to improve the self-management ability of discharged patients so that they can effectively deal with complications of radiotherapy and chemotherapy and improve their quality of life.

Material and Methods

Patients

We randomly divided 132 patients admitted to the Rhinology Department of our hospital from March 2015 to March 2017 into 2 groups: 65 patients were assigned to the intervention group and 67 patients were assigned to the control group. Inclusion criteria were: (1) patients with NPC confirmed by histopathology and received radiotherapy and chemotherapy for the first time, (2) had the ability to take care of themselves,

(3) had reading ability, (4) provided informed consent. Exclusion criteria were: (1) severe cardiovascular and cerebrovascular complications, (2) severe cognitive, mental, and language disorders. All patients provided signed informed consent. This research was approved by the Institutional Ethics Committee of First Affiliated Hospital of Zhengzhou University.

Intervention method

Control group: Patients in the control group received a conventional follow-up visit after hospital discharge, in which patients were informed after discharge about relevant issues by their physician, including diet, exercise, and rehabilitation exercise, and were told that they should attend re-examinations at 3 and 6 months after discharge.

In the intervention group, when patients were discharged, they were asked to download the smartphone medical app and complete rehabilitation after discharge according to the app guidelines. The smartphone medical app intervention manager asked patients about their use of the app by telephone follow-up every month. According to characteristics of NPC, the app includes 3 special modules: a re-examination reminder, a knowledge base, and an online expert. With the re-examination reminder, 3 days before the re-examination, the app administrator notifies the patients to review. The knowledge base informs patients consists of text, pictures, and videos, including a rehabilitation exercise video, assessment and treatment of adverse reactions and complications, medication, diet, activities and rest, and psychological guidances. With the online expert, every Wednesday and Saturday, a doctor is scheduled to answer patients' questions online to help doctors know about recovery after discharge. Patients can also interact with other patients, share information about rehabilitation after discharge, and upload rehabilitation pictures.

Data collection and processing

We collected and evaluated data on complications after radiotherapy and chemotherapy, rehabilitation exercise compliance, and quality of life at discharge and at 3 months and 6 months after discharge. Patients were asked to complete a questionnaire and report on their condition according to uniform instructions, and this process was completed by the patients themselves. Patients were contacted by telephone to remind them about follow-up at 3 and 6 months, and at the same time complete the patient condition form. Patients who could not go to the hospital for re-examination were followed-up by mail or telephone.

Statistical analysis

SPSS17.0 software was used for statistical analysis. Enumeration data were checked by chi-square test, and the

Table 1. Demographic and health characteristics of the participants.

Items	Classification	Intervention group (N1=65) $\bar{x} \pm n$ (%)	Control group (N2=67) $\bar{x} \pm n$ (%)	t/ χ^2	P
Gender	Male	39 (60.0)	44 (65.7)	0.009	0.924
	Female	26 (40.0)	23 (34.3)		
Age (Yr)		44.32±11.03	42.28±10.37	0.883	0.463
Course of disease	IV stage	11 (16.9)	13 (19.4)	1.067	0.587
	III stage	28 (43.1)	29 (43.3)		
	II stage and below	26 (40.0)	25 (37.3)		
Chemotherapy regimen	Single chemotherapy	45 (69.2)	49 (73.1)	0.135	0.714
	Combination chemotherapy	20 (30.8)	18 (26.9)		
Radiotherapy regimen	Conventional radiotherapy	18 (27.7)	16 (23.9)	0.025	0.875
	Intensity modulated radiation therapy	47 (72.3)	51 (76.1)		

independent-samples *t* test was used to assess the data. Rank data were tested by rank sum test method, and the level of test was 0.05 ($\alpha=0.05$).

Results

Basic information

We divided the 132 patients with NPC who received radiotherapy and chemotherapy for the first time, in accordance with the random number table method, into a control group (67 patients) and an intervention group (65 patients) (Table 1). There was no significant difference between the 2 groups in gender, age, course of disease, or chemotherapy and radiotherapy regimens ($P>0.05$).

Comparison of radiotherapy and chemotherapy complications

Table 2 compares complications in the 2 groups, including xerostomia, oral mucositis, hearing loss, mouth-opening difficulties, and nasal congestion. Patients had varying degrees of xerostomia, oral mucositis, hearing loss, mouth-opening difficulties, and nasal congestion at discharge. There was no significant difference in the incidence of these complications between the 2 groups ($P>0.05$). Xerostomia was the most common complication, and the incidence rates in the 2 groups were 89% and 92%, respectively.

At 6 months after discharge, the incidence and severity of oral mucositis, mouth-opening difficulties, xerostomia, and nasal obstruction in the intervention group was significantly

lower than that in the control group, and there was a significant difference between the 2 groups ($P<0.05$). This indicated that the intervention had positive effects on improving xerostomia and oral mucositis for discharged patients. The app knowledge base includes measures to improve the incidence of these complications, such as encouraging patients to rinse with dilute saline and use sodium bicarbonate mouthwash, keep the mouth clean, increase intake of liquids, jointly present nasal irrigation content in the form of pictures and videos, and help patients improve cognitive level and compliance, so as to improve the symptoms of nasal congestion.

Comparison of compliance of rehabilitation exercise between 3 and 6 months after discharge

Taking mouth-opening exercises and nasal irrigation compliance as examples, the results of rehabilitation training compliance are shown in Table 3. Results showed that the compliance of mouth-opening exercises and nasal irrigation in the intervention group was higher than that in the control group at 3 and 6 months after discharge ($P<0.05$). The incidence of mouth-opening difficulties and nasal congestion was significantly lower than in control group at 6 months after discharge, indicating that the smartphone app can effectively improve the symptoms of mouth-opening difficulties and nasal congestion.

Comparison of quality of life between the 2 groups at 6 months after discharge

Quality of life in the 2 groups after discharge was investigated using the Quality of Life Questionnaire (QLQ-C30) [11], which was designed by the European Cancer Treatment Research

Table 2. Comparison of side effects and complications of radiotherapy and chemotherapy in two groups [N (%)].

Items	Grade	At discharge				6 months after discharge			
		Group C N1=65	Group I N2=67	Z/ χ^2	P	Group C N1=65	Group I N2=67	Z/ χ^2	P
Oral mucositis	0	8 (12)	13 (19)	-0.757	0.449	34 (52)	52 (78)	-2.138	0.033
	I-II	40 (61)	40 (59)			29 (45)	12 (19)		
	III-IV	17 (27)	14 (22)			2 (3)	3 (3)		
Mouth opening difficulties	0	16 (24)	15 (22)	0.000	1.000	23 (36)	45 (68)	-2.397	0.017
	I-II	38 (58)	42 (63)			31 (48)	14 (22)		
	III-IV	11 (18)	10 (15)			11 (16)	8 (10)		
Xerostomia	0-I	39 (60)	43 (64)	-0.503	0.615	42 (65)	51 (76)	-2.335	0.020
	II-III	26 (40)	24 (36)			23 (35)	16 (24)		
Hearing loss	Without	20 (31)	19 (29)	0.010	0.919	22 (34)	24 (36)	0.545	0.460
	Exist	45 (69)	46 (71)			43 (66)	43 (64)		
Nasal congestion	0	12 (18)	17 (25)	1.220	0.223	25 (39)	37 (56)	-2.084	0.037
	I-II	29 (45)	35 (53)			25 (39)	25 (38)		
	II-III	24 (37)	15 (22)			15 (22)	5 (6)		

Group C is control group, and Group I is intervention group.

Table 3. Comparison of rehabilitation exercise compliance between two groups of patients after discharge [N (%)].

Items		3 months after discharge				6 months after discharge			
		Group C N1=65	Group I N2=67	Z/ χ^2	P	Group C N1=65	Group I N2=67	Z/ χ^2	P
Compliance of mouth opening exercise	Full compliance	8 (12)	20 (19)	6.610	0.037	5 (12)	8 (19)	7.369	0.013
	Partial compliance	40 (61)	36 (59)			23 (6)	33 (59)		
	Non-compliance	17 (27)	11 (22)			37 (2)	26 (22)		
Compliance of nasal irrigation	Full compliance	12 (12)	24 (19)	3.685	0.048	8 (12)	16 (19)	8.356	0.015
	Partial compliance	20 (61)	16 (59)			34 (61)	19 (59)		
	Non-compliance	33 (27)	27 (22)			23 (27)	32 (22)		

Group C is control group, and Group I is intervention group.

Organization (EORTC; Table 4). At 6 months after discharge, quality of life scores of control and intervention groups were better than at discharge, indicating that most patients had improved quality of life. In the functional and overall quality of life field, scores of the intervention group were higher than in the control group at 6 months after discharge (P<0.05). In the area of symptoms, scores of fatigue and pain in the intervention

group were lower than those in the control group (P<0.05). In the single area, such as sleep loss, appetite loss, and constipation, the scores of the intervention group was lower than that of the control group (P<0.05). The results indicated that the app can further improve fatigue, pain, sleep loss, appetite loss, constipation, and other symptoms, which is helpful to further improve the overall quality of life of patients.

Table 4. QLQ-C30 questionnaire of two groups at discharge and 6 months after discharge.

Field	At discharge				6 months after discharge				
	Group C	Group I	t	P	Group C	Group I	t	P	
Functional field	PF	59.62±12.18	58.79±10.58	0.293	0.771	80.22±11.35	91.36±8.63	4.444	<0.001
	RF	55.86±16.53	56.33±14.69	0.121	0.904	63.54±14.23	72.18±10.13	2.812	0.007
	EF	53.29±12.36	54.18±12.68	0.287	0.775	62.53±11.34	73.62±10.21	4.139	<0.001
	CF	73.22±13.25	74.37±14.76	0.331	0.742	77.63±12.31	83.14±10.64	1.928	0.049
	SF	57.89±17.46	56.37±16.35	0.362	0.719	70.54±15.14	76.91±12.19	1.572	0.121
Symptom field	FA	52.09±16.49	53.82±18.32	0.400	0.690	38.64±13.32	22.14±12.54	5.139	<0.001
	NV	20.98±12.69	21.56±11.02	0.196	0.845	2.54±5.61	2.13±4.96	0.311	0.756
	PA	55.46±20.41	57.21±21.35	0.338	0.737	8.24±11.75	3.12±8.36	2.018	0.048
	DY	10.21±14.56	12.84±13.24	0.761	0.449	2.34±9.63	2.11±8.54	0.102	0.919
	SL	61.02±22.12	59.74±21.36	0.237	0.813	13.14±20.11	6.13±16.58	1.531	0.131
	AP	73.82±23.12	71.21±21.58	0.481	0.632	9.62±10.54	3.28±8.56	2.657	0.009
	CO	15.34±16.57	16.40±15.80	0.264	0.792	8.11±12.33	3.82±9.22	1.585	0.118
	DI	5.39±10.50	6.10±9.44	0.286	0.776	5.10±8.51	5.86±8.47	0.361	0.719
FI	43.85±34.17	41.28±35.11	1.867	0.067	39.66±30.12	38.22±31.01	0.190	0.850	
Overall quality of life field	QL	34.15±10.31	32.14±9.65	0.811	0.420	62.15±11.17	72.03±9.07	3.908	<0.001

Group C is control group, and Group I is intervention group. PF – physical functioning; RF – role functioning; EF – emotional functioning; CF – cognitive functioning; SF – social functioning; FA – fatigue; NV – nausea and vomiting; PA – pain; DY – dyspnoea; SL – sleep loss; AP – appetite loss; CO – constipation; DI – diarrhoea; FI – financial difficulties; QL – quality of life.

Discussion

With the progress of society and the change of medical mode, evaluation of the effect of cancer treatment focuses more on improvement of quality of life after treatment [12]. After receiving radiotherapy and chemotherapy, patients with NPC have varying degrees of complications and adverse reactions, physical damage, and reduction of social function, which puts patients under great pressure, and quality of life can be seriously affected.

Patients and their families lack understanding of the disease system and pay great attention to treatment in the hospital, but they despise the rehabilitation exercise treatment and follow-up visit after the operation and discharge [13]. Studies have shown that the quality of life of cancer patients is related to their optimistic attitudes towards life [14]. Use of an app can enhance the communication between doctors and patients, and it can be fast and convenient for doctors to provide health information to patients and develop some appropriate measures and methods to relieve nervousness and anxiety of

patients as well as help them actively carry out functional exercises [15,16]. Moreover, the app allows physicians to keep abreast of the patient's condition and quickly provide comprehensive and systematic treatment, care, and rehabilitation and carry out a timely follow-up [17].

Patients may suffer from mouth-opening difficulties, nasal congestion, and other symptoms after their discharge, among which mouth-opening difficulties are the more severe complication [18], the incidence of which first decreased and then increased. At 1–2 months after discharge, the incidence of mouth-opening difficulties was the highest, and then gradually decreased as oral mucosa injuries healed. At about 6 months after discharge, mouth-opening difficulties occurred again. It is an effective method to prevent and reduce the incidence and severity of mouth-opening difficulties by early opening mouth exercises and keeping on doing the exercise [19–21]. In the app, there are mouth-opening exercises videos, and it is necessary to encourage patients to follow the video every day and do it; patients should adhere to exercise even if early oral mucositis and xerostomia occur after radiotherapy.

Due to the sustained rehabilitation exercise of the intervention group, the incidence and severity of mouth-opening difficulties were lower than in control group ($P < 0.05$).

In addition, nasal lavage can alleviate nasal mucosa swelling, dryness, nasal congestion, and other adverse reactions. There are pictures and videos co-presented about nasal irrigation and other operations in the app, so that patients can easily understand and master the correct methods. The pictures and videos can be watched repeatedly, which can improve cognitive level and compliance.

Nasal irrigation can reduce the nasal swelling, dryness, nasal obstruction, and other adverse reactions of NPC patients after radiotherapy. It can also promote normal mucosal repair and reduce the incidence of complications [22]. After the patient is discharged, it is necessary to improve the compliances using nasal lavage. All these activities can be performed with the help of the relevant videos to improve patient compliance. Consistent and correct performance of exercises can effectively improve patient symptoms.

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Conclusions

This study shows that rational use of a smartphone app can improve exercise compliance of patients with NPC after radiotherapy and chemotherapy, reduce adverse reactions and complications due to radiotherapy and chemotherapy, and improve quality of life and satisfaction after discharge.

Conflict of interest

None.