Original Article
Evaluation of the effect of a three-color ladder management model for knee osteoarthritis in the community

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Abstract: Objective: To explore the application effect of a three-color ladder management system for knee osteoarthritis in the community. Methods: Eighty-six patients with knee osteoarthritis in our community were obtained for study and randomly grouped. The control group received routine management, while the research group received three-color ladder management for 12 months. The knee joint function (WOMAC score), pain degree (VAS score), joint flexibility, health-related behavior score, self-care ability scale (exercise of self-care agency scale (ESCA) score), quality of life (knee osteoarthritis quality of life scale (AIMS2-SF) score) and knee replacement rate were compared between the two groups before and after management, and the changes of patients' visits and treatment costs before and after management were observed. Results: After 12 months, the scores of WOMAC and VAS in the research group were significantly lower than those of the control group (P<0.05), while the scores of joint flexibility and extension, cognition, behavior and condition of Omaha System health-related behaviors, ESCA and AIMS2-SF were significantly higher than those of the control group (P<0.05). After 12 months, the monthly visits and expenses of green cards, yellow cards and red cards in the research group were significantly lower than those before entering the group (P<0.05). After 12 months, the knee replacement rate was 20.93% (9/43) in the research group, while it was 27.91% (12/43) in the control group, with no significant difference between the two groups (P>0.05). Conclusion: The three-color ladder management system for knee osteoarthritis patients in the community can reduce the number of doctor visits and overall expenses, improve knee joint function, reduce pain, improve self-management ability and quality of life, and it has high community popularization.

Keywords: Community, knee osteoarthritis, three-color ladder, quality of life

Introduction

Knee osteoarthritis is a degenerative bone disease, and it is characterized by hyperosteogeny, degeneration and loss of articular cartilage. Patients with knee osteoarthritis are often accompanied by pain, swelling and stiffness of the knee joint, and limited movement. Severe cases may have limb deformity, which affects the quality of life [1, 2]. This disease often occurs in middle-aged and elderly people, mainly because the cartilage of the knee joint in older people easily degenerates, thus causing abnormal bone metabolism of knee joint, bone inflammation around the cartilage, and finally induces dysfunction and pain [3].

Community health service focuses on elderly patients with chronic diseases, and knee osteo-

arthritis is one of these chronic diseases, so the effective prevention and treatment of this disease requires the participation of community health management [4]. Community health service institutions can help patients return to society sooner by comprehensively recording their illness, identifying risk factors, regularly following up, and rationally adjusting treatment and nursing programs according to the changes of illness [5]. With the advancement of the new round of comprehensive community reform, problems such as insufficient two-way referral, incomplete drugs, insufficient compulsion of the first diagnosis system and lack of general practitioners are becoming more serious, which not only hinders the formation of graded diagnosis and treatment systems, but also affects the comprehensive development

of health management [6, 7]. The three-color ladder management system is mostly applied for early warning of critically ill patients and hospitalized patients. According to the characteristics of patients' illness and the frequency of visits, medical staff can take targeted evaluation and intervention measures, which has a high application value in risk warning [8]. In addition, in the long term prescription management of chronic diseases, the three-color ladder management system has achieved certain results, which can reduce the number of hospital visits and reduce the workload of family doctors' outpatient services [9, 10]. However, there is no report on the therapeutic effect of this management mode in knee osteoarthritis. In view of this, we established a three-color ladder management system according to the stability and severity of knee osteoarthritis patients, and standardized the service process and content, aiming at providing a basis for the health management of community patients. The details are reported as follows.

Materials and methods

General data

From February 2017 to February 2019, 86 patients with knee osteoarthritis were selected in our community, including 30 males and 56 females. The patients were aged 42-74 years, with an average of (52.8±5.9) years. The course of disease ranged from 2 to 10 years, with an average of (5.7±1.8) years. Inclusion criteria: patients were aged 40-75 years; the research met the diagnostic criteria of knee osteoarthritis in the Guideline of Diagnosis and Treatment of Osteoarthritis (2010 Edition) [11]. X-ray film showed that osteophyte was present in one knee. Informed consent was obtained. This research met the requirements of the Medical Ethics Committee of our hospital. Exclusion criteria: patients with secondary knee osteoarthritis, gout, or rheumatoid arthritis; patients with a history of knee surgery and neurological diseases of lower limbs; patients accompanied by coagulation dysfunction, systemic infectious diseases or knee joint infection; patients who had a history of vascular injury, tuberculosis, tumor, bone rigidity in in knee joint or congenital malformation of lower limbs; patients accompanied by serious diseases such as endocrine, cardiovascular or cerebrovascular diseases; patients with cognitive dysfunction, mental disorder or communication disorder; patients who could not receive follow-up, were lost to follow-up, withdrew or died.

Methods

Control group: Routine management: the disease condition was observed; knee protection and functional exercise were performed; the patients were regularly followed-up; the life care, consultations and home services were conducted. In addition, a special lecture was held quarterly for patients, and the medication was adjusted according to their illness.

Research group: Three-color ladder management: (1) A three-color ladder management team was established with the "1+3+X" management mode, in which 1 indicates the head (planner) of community health service institution, 3 indicates a health manager, a general practitioner, a community nurse (practitioner), and X indicates several community volunteers and specialists (collaborators). According to the basic service process of the community ladder management, the qualification requirements and responsibilities of team members were formulated. (2) Patients' information was collected through household follow-up, general outpatient service, telephone consultation, free community clinics and physical examination, and high-risk groups were screened out. A personal health record was established by Problem-Oriented Medical Record (POMR), and the patient's diagnosis and treatment history, disease development process and personal health problems were recorded in detail. (3) A three-color ladder management was established. Referring to the standard of Expert Consensus on Knee Osteoarthritis Ladder Treatment (2018 edition) [12]. The patients were correlated to the green card, yellow card and red card according to the pain degree, laboratory examination, X-ray manifestations and symptoms and signs at the first visit. The card of the corresponding color was distributed to patients, and patients were told to show their cards at the time of return visit. Then, the card colors were determined again according to the conditions of the disease after the return visit, so as to realize any dynamic adjustment. Both groups were managed for 12 months. The details were shown in **Table 1**.

Table 1. Three-color ladder management framework and mode of knee osteoarthritis

Items	Green card	Yellow card	Red card
Management	After long-term activities or mountain climbing, the symptoms of knee joint were aggravated; X-ray film showed grade 0 and grade 1; the physical examination showed that patellar grinding test and floating patellar test were (-), and the over flexion test were (+). The flexibility of motion was acceptable, and there was a tenderness around the joint and in front of the patella, the joint movement was slightly limited with or without mild swelling.	X-ray showed grade II and grade III; patella grinding test showed (-), flexion test showed (+), patellar floating test showed (+) or (-); the joint activity was acceptable, and there was a tenderness at the medial or lateral collateral ligament of the knee joint with severe pain.	The joint pain was aggravated when going up and down stairs or walking, and there was knee joint eversion or varus, or joint stiffness; X-ray film showed grade IV; patellar grinding test showed (+), patellar floating test showed (+), flexion test showed (+), and the tenderness around patella of knee joint was obvious.
Establishment of health records	immediately	immediately	immediately
Follow-up frequency	3 times/year	1 time/quarter	1 time/month
Management scheme	Health interventions such as dietary therapy and medicinal food, daily life, emotional adjustment, and exercise; Personalized health education such as aerobic exercise, weight loss and self-behavior therapy; Health education such as distribution of the health manuals, lectures, and videos for patients to understand the etiology, pathogenesis, treatment and outcome.	Reinforcement of medical consultation and health education on the basis of green card; exercise therapy such as muscle strength training and functional training; physical therapy such as traction, hydrotherapy, hyperthermia, acupuncture and massage.	Disease management on the basis of yellow card, including action support for patients such as walk aid instrument, walking sticks and crutches; orthopedic shoes, orthopedic braces for changing the weight bearing strength; active treatment for complicated diseases.
Drug treatment		According to the degree of joint pain, joint cavity injection and general analgesia drugs were selected.	Immediate application of standardized drug treatment was performed; If necessary, surgical treatment was required.
Referral	It was recommended to receive medical services from primary health institutions.	If the condition did not improve or worsened after non-drug treatment, it was recommended to turn to a specialized hospital.	It was recommended to be hospitalized in a specialized hospital.
Management objectives	Recovery of joint function, reduction of pain and improvement of mastery of health knowledge.	Improvement of joint function, pain and deformity.	Inhibition of disease progression; Further assistance in diagnosis and treatment; Improvement of joint function.

Outcome measures

Main outcome measures: (1) Knee joint function. The WOMAC scale involved knee pain degree (5 items), stiffness degree (2 items) and joint function (17 items), with a total of 24 items, and each item was scored 0-4 points [13]. A higher score indicates a worse knee joint, and the evaluation time was at the time of enrollment and 12 months after enrollment. (2) Pain degree and joint flexibility. The VAS scale was applied, with the score range of 0-10 points, representing painless to severe pain. The flexibility of the joint was measured by a protractor, and the evaluation time was at the time of enrollment and 12 months after enrollment. (3) Number and cost of visits. The monthly visits and expenses of a green card, yellow card and red card in the research group were counted at the time of enrollment and 12 months after enrollment.

Secondary outcome measures: (1) Health-related behaviors. At the time of enrollment and 12 months after enrollment, the scores of cognition, behavior and status of Omaha System health-related behaviors were evaluated. A Likert 5-grade scoring method was used, and a higher score indicated lighter problems. (2) Self-management ability and quality of life. Exercise of Self-Care Agency Scale (ESCA) and knee osteoarthritis quality of life scale (AIMS2-SF) were applied to evaluate patients' self-management ability and quality of life at the time of enrollment and 12 months after enrollment [14]. The ESCA scale involved 5 dimensions with a total score of 172 points, and a higher score indicated stronger self-care ability. AIMS2-SF scale involved five dimensions, with a total score of 104 points, and a high score indicated a better quality of life. (3) Knee replacement rate of the two groups after 12 months was observed.

Statistical methods

SPSS 23.0 was applied for data processing, and the measurement data were expressed as a mean ± standard deviation ($\overline{x}$ ± sd). Independent sample t and paired t tests were applied for comparison between groups and within groups before and after intervention, respectively, and the counting data were expressed in percentage and analyzed by χ^2 test. The difference was statistically significant when $P<0.05$.

Results

General data

There were no significant differences in general data (age, sex, course of disease, lesion location, Kellgren-Lawrence grade, complications, family monthly income, etc.) between the research group and the control group ($P>0.05$; **Table 2**).

WOMAC scores

After 12 months, the pain, stiffness and joint function scores of WOMAC scale in the two groups were decreased, and those of the research group were lower than those of the control group ($P<0.05$; **Table 3**).

VAS score and joint flexibility

After 12 months, the VAS score decreased in the two groups and the joint flexibility improved, and the VAS score of the research group was lower than that of the control group ($P<0.05$; **Table 4** and **Figure 1**).

Scores of cognition, behavior and status of health-related behaviors in the Omaha system

The scores of cognition, behavior and status of Omaha System health-related behaviors of the two groups increased 12 months after enrollment, and the scores of the research group were higher than those of the control group ($P<0.05$; **Table 5** and **Figure 2**).

Self-management ability and quality of life

After 12 months, the ESCA score and AIMS2-SF score both increased, and the scores of the research group were higher than that of the control group ($P<0.05$; **Table 6** and **Figure 3**).

Comparison of the number of visits and expenses before and after the enrollment

The monthly visits and expenses of the green card, yellow card and red card in the research group after 12 months were all lower than those before the enrollment ($P<0.05$; **Table 7**).

Table 2. Comparison of two groups of general information (n, x̄ ± sd)

Group	Control group (n=43)	Research group (n=43)	χ^2/t	P
Male/female	16/27	14/29	0.205	0.651
Age (years)	53.4±5.7	52.1±6.1	1.021	0.310
Course of disease (years)	5.3±4.3	5.8±4.1	0.552	0.583
BMI (kg/m^2)	22.98±2.37	23.37±2.25	0.783	0.436
Education			0.511	0.537
Junior high school and below	16	13		
High school and technical secondary school	17	21		
Junior college and above	10	9		
Lesion location			0.321	0.725
Left	18	17		
Right	20	23		
Bilateral	5	3		
Kellgren-Lawrence grade			0.796	0.372
Grade II	29	25		
Grade III	14	18		
Complications				
Diabetes	7	5	0.387	0.534
Hypertension	12	11	0.059	0.808
Osteoporosis	19	21	0.187	0.665
Family monthly income (yuan/month)			0.580	0.748
<5000	15	12		
5000-8000	20	21		
>8000	8	10		
Live alone	12	15	0.486	0.486

Note: Body mass index.

Table 3. Comparison of WOMAC scores between the two groups (x̄ ± sd, scores)

Group	Control group (n=43)	Research group (n=43)	t	P
Pain degree				
At the time of enrollment	13.06±3.21	13.26±3.45	0.278	0.782
12 months after enrollment	10.16±2.94[***]	7.03±1.13[***]	6.516	<0.001
Stiffness				
At the time of enrollment	12.94±3.37	13.43±4.05	0.610	0.543
12 months after enrollment	9.65±2.16[***]	6.62±2.05[***]	6.672	<0.001
Joint function				
At the time of enrollment	14.32±3.29	14.58±3.81	0.339	0.735
12 months after enrollment	11.06±2.09[***]	8.67±2.45[***]	4.867	<0.001

Note: Compared with this group when it was entered into the group, [***]P<0.001.

Keen replacement rate

The rate of knee replacement in the research group was 20.93% (9/43), while 27.91% (12/43) in the control group after 12 months, with no significant difference between the two groups (χ^2=0.567, P=0.451).
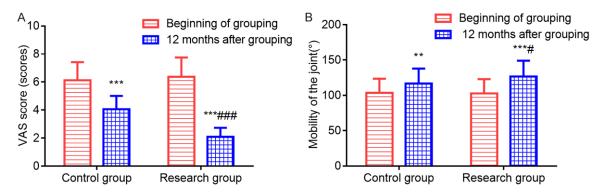
Discussion

Rehabilitation training for knee osteoarthritis patients is a complex process, which requires long-term professional intensive training. In this process, patients are prone to bad emotions, and it is difficult to adhere to medical

Table 4. Comparison of VAS scores and joint flexion and extension activities between the two groups ($\bar{x} \pm$ sd)

Group	Control group (n=43)	Research group (n=43)	t	P
VAS score (scores)				
At the time of enrollment	6.13±1.29	6.38±1.37	0.871	0.386
12 months after enrollment	4.06±0.95***	2.10±0.64***	11.220	<0.001
Joint flexion and extension (°)				
At the time of enrollment	103.64±19.94	102.67±20.18	0.224	0.823
12 months after enrollment	116.67±21.28**	126.78±22.37***	2.147	0.035

Note: Compared with this group when entering the group, **$P < 0.01$, ***$P < 0.001$.

Figure 1. Comparison of VAS scores and joint flexion and extension activities between the two groups. A: VAS score; B: Joint flexion and extension range of motion. Compared with this group when entering the group, **$P < 0.01$, ***$P < 0.001$; compared with the control group, #$P < 0.05$, ###$P < 0.001$.
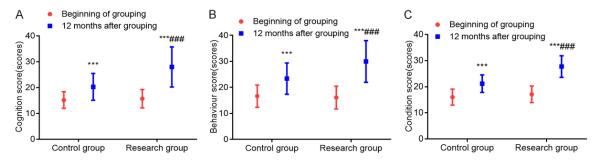
Table 5. Scores of cognition, behavior and status of health-related behaviors in the Omaha system ($\bar{x} \pm$ sd, scores)

Group	Control group (n=43)	Research group (n=43)	t	P
Cognition				
At the time of enrollment	15.16±3.21	15.68±3.56	0.711	0.479
12 months after enrollment	20.26±5.18***	27.94±7.76***	5.398	<0.001
Behavior				
At the time of enrollment	16.64±4.29	16.08±4.37	0.600	0.550
12 months after enrollment	23.37±6.02***	29.97±8.02***	4.316	<0.001
Status				
At the time of enrollment	16.02±3.06	17.12±3.16	1.640	0.105
12 months after enrollment	21.19±3.37***	27.74±4.16***	8.023	<0.001

Note: Compared with this group when it was entered into the group, ***$P < 0.001$.

drugs and make regular follow-up visits [15]. As most patients receive rehabilitation services in the community after discharge, it is particularly critical to develop a continuous and holistic community health service system in order to ensure patients enjoy a seamless diagnosis and treatment services and accelerate the recovery of the disease [16, 17]. Based on the community health management practice of knee osteoarthritis in health service centers,

this study intended to make clear the distribution of health problems in the knee osteoarthritis population in the community, and formulate a tagging management system of a three-color ladder to guide the standardized development of health management of this population.
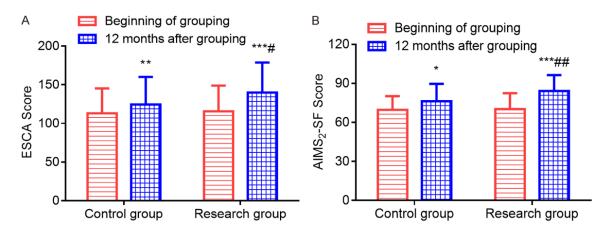
In this study, compared with the control group, the WOMAC score and VAS score in the research group were lower, while the joint flexibility, cog-

Figure 2. Scores of cognition, behavior and status of health-related behaviors in Omaha system. A: Cognitive score; B: Behavior score; C: Condition score. Compared with this group when entering the group, ***P<0.001; compared with the control group, ###P<0.001.

Table 6. Comparison of ESCA and AIMS2-SF scores between the two groups ($\bar{x}$ ± sd, scores)

Group	Control group (n=43)	Research group (n=43)	t	P
ESCA score				
At the time of enrollment	113.04±32.18	115.58±33.37	0.359	0.720
12 months after enrollment	124.49±35.58**	139.97±38.81***	2.052	0.043
AIMS2-SF score				
At the time of enrollment	69.62±10.57	70.29±12.14	0.273	0.786
12 months after enrollment	76.27±13.37*	84.17±12.19***	2.863	0.005

Note: Compared with this group when entering the group, *P<0.05, **P<0.01, ***P<0.001.

Figure 3. Comparison of ESCA and AIMS2-SF scores between the two groups. A: ESCA score; B: AIMS2-SF score. Compared with this group when entering the group, *P<0.05, **P<0.01, ***P<0.001; compared with the control group, #P<0.05, ##P<0.01. AIMS2-SF: knee osteoarthritis quality of life scale; ESCA: exercise of self-care agency scale.

nition, behavior and status score of Omaha system health-related behaviors, ESCA score and AIMS2-SF score were higher, indicating that the implementation of the three color ladder management system for knee osteoarthritis patients in the community was helpful for improving the knee joint function and quality of life of patients, and enhancing the awareness rate of health knowledge and self-care ability.

The reasons are as follows. According to the degree of pain, laboratory examination, X-ray manifestations, symptoms and signs of patients, the personal health records were established by POMR, in which patients were given a green card, yellow card and red card respectively, which was helpful to the nursing work [18, 19]. Among them, health education is the main focus for green card patients. By play-

Table 7. Comparison of the number of visits and expenses in the research group before and after admission ($\overline{x} \pm$ sd)

Group	Number of visits (times/month)			Medical expenses (yuan/month)		
	Green card	Yellow card	Red card	Green card	Yellow card	Red card
At the time of enrollment (n=43)	0.86±0.41	2.38±0.46	3.97±0.72	162.34±13.38	406.21±30.41	851.26±39.87
12 months after enrollment (n=43)	0.56±0.28	1.45±0.74	2.61±0.55	154.49±14.75	365.14±29.94	769.52±37.71
t	3.962	6.999	9.843	2.585	6.311	9.767
P	<0.001	<0.001	<0.001	0.011	<0.001	<0.001

ing videos, giving lectures, distributing health manuals, explaining the etiology, pathogenesis, treatment and outcome of diseases to patients, the patients' compliance with rehabilitation treatment and the understanding of prevention and treatment knowledge were improved, so as to correct previous unhealthy lifestyles, improve their ability to perceive diseases and self-manage, reduce the risk factors of knee osteoarthritis such as excessive knee movement and being overweight, and improve their quality of life. In addition, personalized health support can eliminate tension, scruples and other bad emotions, relieve lower limb muscle tension and vasospasm, and reduce the degree of pain [20-22]. Exercise therapy and physical factor therapy are the main methods for patients with yellow card, among which muscle strength training and exercise training can enhance the muscle strength around the knee joint, improve the endurance and strength of the tissues around the knee joint (such as ligaments, tendons, muscles, and joint capsules), and improve the stability of the knee joint. Physical therapy such as traction, hydrotherapy and hyperthermia can effectively alleviate synovitis, regulate local blood circulation and synovial fluid secretion, reduce intraosseous high pressure, release adhesion, relieve muscle spasms, and then delay cartilage degeneration, as well as accelerate articular cartilage metabolism and improve knee joint function [23]. For the red card patients, drug treatment and assistive devices adaptation are applied. Drug treatment includes intra-articular injection and general analgesic drugs, which can alleviate the disease and improve the knee joint function. Assistive devices adaptation can speed up the process of joint function recovery, reduce the burden of family members, and then realize the mutual assistance mode of community and family participation.

After the implementation of the three-color ladder management mode, the monthly visits and expenses of the green card, yellow card and red card patients were all reduced, indicating that the implementation of the three-color ladder management system can save patients' medical expenses and reduce the number of visits. Under the three-color ladder management mode, systematic and standardized risk classification management is implemented, risk factors are identified early, and individualized management schemes are carried out. Green card patients can receive treatment in community hospitals and be followed up regularly [24, 25]. For yellow card patients, medical consultation and health education were strengthened, and corresponding exercise and physical therapy are performed. According to the degree of joint pain, joint cavity injection and general analgesia drugs were selected. If the condition is not improved, it is recommended to go to a specialized hospital. For patients with red card, it is recommended to be transferred to a specialized hospital for comprehensive and systematic treatment, and then return to community hospitals for treatment after the condition is stable, which can help patients get corresponding treatment and prevention strategies at different stages of the disease and inhibit the further aggravation of the disease. At the same time, this model can realize the sharing and interaction of skills and knowledge between community hospital and specialized hospitals, and provide timely and advanced follow-up, prevention and treatment services for patients. In addition, the establishment of close cooperation between specialized hospital and community hospitals can make rational use of medical resources, give full play to their respective functions and advantages, promote the popularization and renewal of disease screening skills and related theoretical knowledge at the basic level, and thus improve the efficiency of nursing work [26-28]. However, the sample size of this study is small, the follow-up time is short, and the observation indexes such as disease complications are not compared. Therefore, we

will further extend the follow-up time, expand the sample size, further adjust and optimize the three-color ladder management mode, and continue to observe the application feasibility of this mode in the future.

To sum up, the application of the tricolor ladder management system in knee osteoarthritis patients in the community can reduce the number of visits and expenses, improve knee joint function, reduce pain, improve self-management ability and quality of life, and it has a high level of popularization in the community.

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Disclosure of conflict of interest

None.

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