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Original Article

Prevention and control of venous thromboembolism after major orthopedic surgery through doctor-to-patient cultivation of musculoskeletal ability based on King's theory of goal attainment

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Abstract: Objectives: To explore the prevention and management of venous thromboembolism (VTE) following major orthopaedic surgery (MOS) by fostering doctor-to-patient cultivation of musculoskeletal ability, guided by King's theory of goal attainment. Methods: A cohort of patients (n = 116) undergoing MOS was selected for the study, and were divided into two groups: the regular group and the observation group, with patients in the regular group experiencing routine nursing care and management and those in the observation group undergoing musculoskeletal ability cultivation based on King's theory of goal attainment. Baseline data, limb vascular ultrasonography, coagulation function, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, VTE prevention efficacy, Exercise of Self-care Ability Scale (ESCA) score, and nursing satisfaction were analysed comparatively. Results: There was no significant within-group difference in baseline data ($P > 0.05$). Following the interventions, the observation group demonstrated statistically significant reductions in the Musculoskeletal-Integrated Imaging Score, various dimensions of WOMAC scores, and D-dimer (D-D) levels ($P < 0.05$) both in comparison to their levels before interventions and to those observed in the regular group ($P < 0.05$). Additionally, the observation group exhibited increases in prothrombin time levels and various dimensions of ESCA scores ($P < 0.05$) post-intervention, surpassing the pre-intervention levels and those obtained in the regular group ($P < 0.05$). Furthermore, the observation group exhibited a significantly lower incidence of VTE ($P < 0.05$) and higher nursing satisfaction ($P < 0.05$) compared to the regular group. Conclusions: Nursing intervention measures, utilizing doctor-to-patient cultivation of musculoskeletal ability based on King's theory of goal attainment, have demonstrated a significant clinical benefit for VTE prevention and control in post-MOS patients. This approach not only effectively prevented VTE in post MOS patients but also enhanced their satisfaction towards nursing care.

Keywords: King's theory of goal attainment, cultivation of doctor-to-patient cultivation of musculoskeletal ability, major orthopaedic surgery, venous thromboembolism

Introduction

Venous thromboembolism (VTE), a potentially fatal yet preventable chronic condition, encompasses deep venous thrombosis (DVT) and pulmonary thromboembolism (PTE). It is characterized by high risks of recurrence, low survival rate, considerable treatment expenses, and a predilection for older adults [1-3]. Epidemiological studies indicate a VTE risk ranging from 104 to 183 cases per 100,000 individuals, with a notably higher incidence among African American populations and a 30% risk of recurrence within a decade [2]. Moreover, VTE is strongly associated with major orthopaedic surgery (MOS), active cancer, and bariatric surgery.

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In addition, aging, obesity, dietary modifications, and diabetes are recognized as prominent risk factors for VTE [4]. Furthermore, prolonged operation time, advanced age, and decreased perioperative mobility, commonly in association with MOS, can significantly elevate the risk of post-MOS VTE [5]. Without preventive measures, the incidence of post-MOS VTE rises from 30.8% to 58.2% [6]. Furthermore, over 1 million MOS, encompassing total hip/knee arthroplasty and hip fracture surgeries, are performed annually in the United States alone [7]. Hence, implementing effective perioperative prevention and control measures for the occurrence of VTE in patients undergoing MOS holds crucial clinical significance in enhancing their overall outcome.

Current strategies for preventing and managing VTE in clinical surgeries primarily revolve around perioperative care, emphasizing chemical prophylaxis, mechanical interventions, and nursing strategies, with patients often positioned in passive roles [8-10]. However, there is a dearth of nursing interventions targeting VTE prevention and treatment that involve active participation from patients at non-high-risk levels. In this study, the doctor-to-patient cultivation strategy aimed at developing the musculoskeletal ability of patients, grounded in King's theory of goal attainment, was employed to foster patients' self-management and adaptability during interventions. By guiding patients within the framework of goal attainment theory, this approach effectively prepared patients with nursing strategies focused on health improvement and proactive steps towards self-care [11, 12]. Built upon the theory of nurse-patient empathy, anticipated compliance, and coordinated interaction, this intervention primarily orchestrated and galvanized the subjective awareness and participation capabilities of stakeholders, including patients' relatives, role supporters, attending physicians, and volunteers. Together, they collaboratively bolstered patients' capacities for disease prevention and control, striving to attain anticipated treatment outcomes [13, 14]. The innovation of this study is twofold: First, the prevention and control interventions for VTE were characterized by nurse-patient collaboration. Through targeted education and guidance in nursing strategies, these interventions enhanced patients' self-management skill and adaptability to clinical treatments, reshaping their mindset and fostering their active engagement in VTE prevention and control, through centring on the principle of personal responsibility for their own health. Second, the intervention approaches facilitated the seamless integration of King's theory of goal attainment with improvement of patients' musculoskeletal health. This integration not only enhanced the effectiveness of patient education and guidance on nursing strategies but also motivated them to proactively engage in health activities, regardless of the discomforts these activities might bring them. By emphasizing the benefits of such activities, these interventions aim to garner patients' attention towards the positive aspects of rehabilitation and achieve optimal recovery. These measures are expected to empower patients to actively participate in the rehabilitation process, surmount pain signals, adopt positive health behaviours, and ultimately enhance the efficacy of nursing interventions [15, 16].

Materials and methods

Sample size estimation

This study adopted a parallel-designed randomized single-blind controlled trial, employing a predetermined ratio between the regular and observation groups. The primary observation indicators focused on nursing interventions for VTE prevention and treatment in patients undergoing MOS. Previous research suggested that the effective rates of routine care and high-quality care for such patients were approximately 87.88% and 96.97%, respectively [17]. The sample size was calculated by the formula as follows: ne=n0=2p (1-p)(μα+μβ) 2/(pe-p0) 2. Here, α was set to 0.05 (bilateral) and β to 0.1 (unilateral). Given that controlling the dropout rate within 10% to 20% is more appropriate, a dropout rate of 15% was established for the study subjects. Utilizing PASS 15 software (NCSS company, USA), the minimum required sample size was determined to be 55 cases per group in this study.

Patient information

The research involved 116 patients undergoing MOS (grades III or IV) at the Affiliated Hospital of Hebei University of Engineering from October 2021 to October 2023. Among them, 56 patients were assigned to the regular group, receiving routine nursing interventions, while

Table 1. Comparison of baseline data between the two groups

Indicator	Regular group (n = 56)	Observation group (n = 60)	χ^2/t	P
Sex			0.502	0.479
Male	29 (51.79)	35 (58.33)		
Female	27 (48.21)	25 (41.67)		
Age (years)	64.84 ± 7.89	68.07 ± 9.75	1.953	0.053
Educational level			0.009	0.926
Below high school	35 (62.50)	38 (63.33)		
High school and above	21 (37.50)	22 (36.67)		
Type of major orthopedic surgery			1.858	0.395
Total hip arthroplasty	22 (39.29)	31 (51.67)		
Total knee arthroplasty	14 (25.00)	11 (18.33)		
Hip fracture surgery	20 (35.71)	18 (30.00)		
Preoperative venous thromboembolism risk			0.890	0.641
Moderate	13 (23.21)	15 (25.00)		
High	28 (50.00)	25 (41.67)		
Extremely high	15 (26.79)	20 (33.33)		

60 patients were designated to the observation group, undergoing doctor-to-patient cultivation of musculoskeletal ability based on King's theory of goal attainment. The regular group comprised 29 males and 27 females, with an average age of (64.8 ± 47.89) years. In comparison, the observation group consisted of 35 males and 25 females, with a mean age of (68.07 ± 9.75) years. Baseline data, including gender and age of patients in the two groups, were comparable (**Table 1**). This study was carried out with the approval from the Affiliated Hospital of Hebei University of Engineering Ethics Committee (2023[K]090), and patients were rigorously screened based on the inclusion and exclusion criteria adopted in the study. The inclusion criteria were as follows: patients eligible for grades III or IV MOS, encompassing total hip/knee arthroplasty and hip fracture surgery; aged ≥ 18 years; hospital stay duration ≥ 3 days; absence of cognitive and communication barriers; availability of intact medical records; and provision of informed consent to participate in the study. The exclusion criteria included the following: patients who declined to receive the management or intervention proposed; presence of VTE upon admission or prior to surgery; patients unable to undergo vascular ultrasonography of limbs; breastfeeding or pregnant individuals; and those afflicted with severe complications.

Nursing intervention measures

Patients receive basic symptomatic treatment. The regular group received routine nursing management and intervention [18]. This involved proactive communication and interactions with patients undergoing MOS, offering them with comprehensive healthcare education on VTE-related disease knowledge, preventive measures, and dietary recommendations. Patients were advised to increase daily water intake, prioritize a light diet abundant in protein and fiber while low in fat, avoid stimulating and greasy foods, and refrain from alcohol and smoking. Additionally, they received guidance on posture, limb warming, continuous disease monitoring, VTE symptom prevention, and adverse drug reaction avoidance, along with early initiation of functional exercises and pain management. These nursing interventions concluded on the day of patient's discharge.

The observation group received the doctor-to-patient cultivation of musculoskeletal ability based on King's theory of goal attainment. A specialized nursing team was formed, comprising professionals from the hospital's health management centre, orthopaedic centre, vascular surgery department and other relevant fields. This team was equipped with comprehensive training in their respective areas of expertise. Doctors from the team oversaw the intervention measures, coordinated intervention processes, and ensured the quality of the interventions, while nurses devised the intervention plans and organized the clinical data of patients. In addition to routine nursing man-

agement and interventions, a preoperative VTE risk assessment was conducted to enable more precise and targeted implementation of preventive measures. Nursing plans were then devised in collaboration with treatment methods. Preoperative VTE risk factors were assessed, encompassing limb immobilization, prolonged bed rest, vascular endothelial inflammation, and blood hypercoagulability. Internationally recognized parameters such as D-dimer (D-D) levels, vascular ultrasonography of limbs, and coagulation function were examined for comparative analysis. Additionally, dynamic evaluation was conducted using the Western Ontario and McMaster Universities Osteoarthritis (WOMAC) Index. Patients received health education aimed at helping them master ankle pump exercises (e.g., ankle dorsiflexion, plantar flexion, internal rotation, and external rotation) and isometric contraction techniques for the gastrocnemius and quadriceps muscles. They were also educated on the significance of maintaining healthy rest habits. Furthermore, efforts were made to cultivate patients' self-management skills in collaboration with the subjective awareness and participation of stakeholders such as patients' relatives, role supporters, attending physicians, and volunteers to collectively enhance patients' abilities to prevent and control VTE. These nursing intervention measures concluded on the day of patients' discharge.

Analysis indices

The primary indices included: (1) Vascular ultrasonography of limbs: The Musculoskeletal-Integrated Imaging Score (MCIS), rated out of 80, was utilized for assessment on the day before and after the interventions, with higher scores indicating greater severity of pathological injury. (2) Coagulation function testing: D-D and prothrombin time (PT) levels were measured before and after the interventions. Venous blood samples (3 mL) were collected from patients both pre- and post-intervention, and the supernatant obtained after centrifugation underwent ELISA quantification of D-D and PT using an automated hematology analyzer. (3) Exercise of Self-care Ability Scale (ESCA): Before and one day after the interventions, the evaluation dimensions, comprising health knowledge level, self-concept, self-responsibility, and self-care skills, were assessed. Each dimension was assigned a maximum score: 80 for health knowledge level, 60 for self-concept, 30 for self-responsibility, and 40 for self-care skills. Higher scores indicated enhanced self-care ability.

Secondary indices included: (1) Baseline data: Sex, age, educational level, type of MOS, and preoperative VTE risks were gathered post-hospitalization for subsequent analyses. (2) WOMAC: Muscle pain, tissue stiffness, and musculoskeletal function were evaluated on the day before and after the interventions. The total WOMAC score, rated out of 96, was directly proportional to the severity of the condition. (3) VTE prevention effect: The number of VTE cases (comprising DVT and PTE cases) in both groups was closely monitored on the day before and after the interventions, and the total incidence was calculated. (4) Nursing satisfaction: A hospital self-designed satisfaction survey questionnaire was used to investigate the satisfaction of patients toward nursing interventions. The total score was 100 points, with scores ≥ 90 indicating very satisfied, 80-90 indicating moderately satisfied and below 80 indicating not satisfied. The total satisfaction was measured as follows: very satisfied + moderately satisfied)/the total number of cases × 100%. The questionnaire response rate was 100%.

Statistical methods

The data collected were compiled into an Excel database, and statistical analyses were performed using SPSS software (version 23.0). Categorical variables such as gender, educational level, surgical type, VTE prevention effects, and nursing satisfaction were presented as frequency (n) and percentage (%), and within-group χ^2 tests were employed for comparative analysis. Continuous variables, including age, MCIS, WOMAC score, ESCA score, and D-D and PT levels, were expressed as mean ± standard deviation. Comparative analyses between groups were conducted using independent sample t-tests. A $P < 0.05$ denoted significance.

Results

Comparison of baseline data between the two groups

Statistical analysis revealed no significant differences in sex ($P = 0.479$), age ($P = 0.053$),

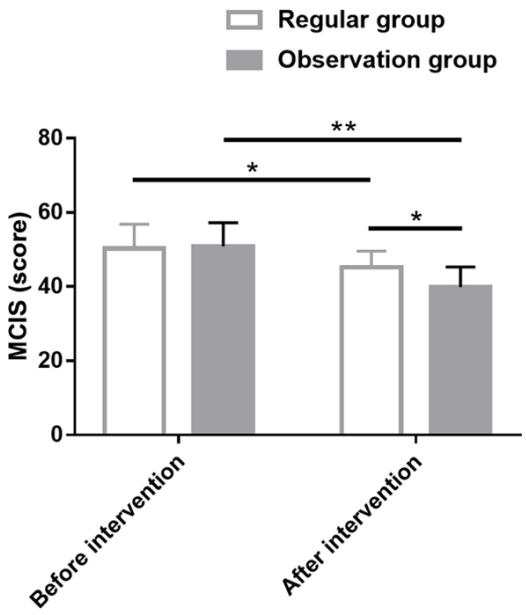

Figure 1. Comparison of limb vascular ultrasonography results in the two groups before and after intervention. Note: MCIS: Musculoskeletal-Integrated Imaging Score; *P < 0.05; **P < 0.01.

educational level (P = 0.926), type of MOS (P = 0.395), and preoperative VTE risks (P = 0.641) between the two groups (**Table 1**).

Comparison of vascular ultrasonography results between the two groups pre- and post-interventions

Upon examination of the MCIS data, no significant differences in the MCIS scores were observed between the two groups before the interventions (P = 0.259). However, following the interventions, there was a notable reduction in the MCIS scores in both groups (P = 0.032, P < 0.001), with lower scores identified in the observation group compared to the regular group (P = 0.021). Please refer to **Figure 1** for graphical representation.

Comparison of coagulation function test results between the two groups pre- and post-interventions

Coagulation function was evaluated by testing D-D and PT levels. Pre-interventional D-D and PT levels were similar between the two groups (P = 0.306 and P = 0.075, respectively). Following the interventions, both groups exhibited significant decreases in D-D levels and increases in PT levels (all P < 0.001), with lower post-interventional D-D levels and higher post-interventional PT levels obtained in the observation group in comparison to the regular group (P = 0.017, P = 0.034, **Figure 2**).

Comparison of WOMAC scores between the two groups pre- and post-intervention

Pre-interventional WOMAC scores for muscle pain, tissue stiffness, musculoskeletal function, and the total WOMAC score did not exhibit statistically significant differences between the two groups (P = 0.856, P = 0.685, P = 0.902 and P = 0.880, respectively). However, following the interventions, these scores significantly decreased, with lower scores observed in the observation group in comparison to the regular group (P = 0.023, P < 0.001, P = 0.013, P < 0.001, **Figure 3**).

Comparison of VTE prevention effects between the two groups

In the regular group, there were 4 DVT cases and 2 PTE cases, whereas in the observation group, there was 1 DVT case and no PTE cases. These findings indicated a significantly lower overall incidence of VTE in the observation group compared to the regular group (1.67% vs. 10.71%, P = 0.041, **Table 2**).

Comparison of self-care ability evaluation between the two groups pre- and post-intervention

The self-care ability of patients in both groups was evaluated using the ESCA scale. No marked within-group differences in the ESCA scores of dimensions including health knowledge level, self-concept, self-responsibility or self-care skills were observed before the interventions (P = 0.118, P = 0.178, P = 0.984, P = 0.673). The scores of all the dimensions showed a significant upward trend after the interventions (all P < 0.001), with higher scores in the observation group than those in the regular group (P = 0.033, P < 0.001, P = 0.017, P < 0.042). See **Figure 4** for details.

Comparison of nursing satisfaction between the two groups

The satisfaction rate of nursing interventions was 95.00% (57 cases) in the observation

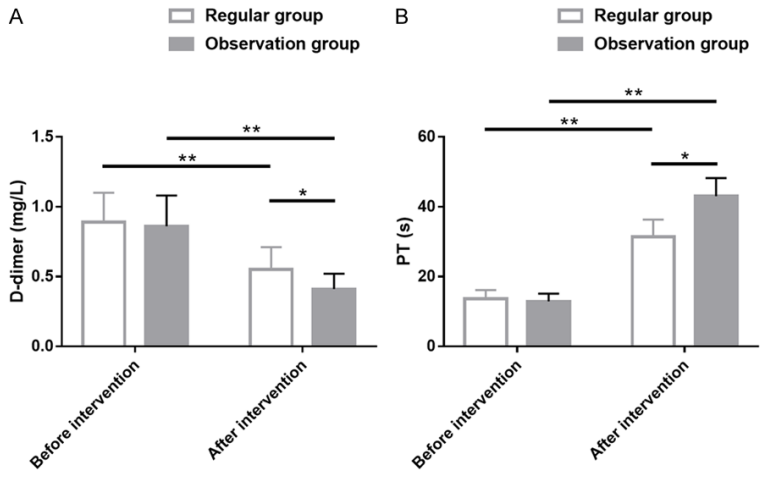

Figure 2. Comparison of blood coagulation function test results between the two groups before and after intervention. A. D-D levels were significantly lower in the observation group. B. PT was significantly higher in the observation group. Note: D-D: D-dimer; PT: prothrombin time; * and ** represent $P < 0.05$ and $P < 0.01$, respectively.

group, which was significantly higher than the 82.14% (46 cases) in the regular group (P = 0.028, **Table 3**).

Discussion

Patients experiencing post-MOS venous thromboembolism (VTE) may exhibit clinical symptoms, such as swelling, lower limb spasm, and discomfort during stretching, significantly impacting their daily lives [19]. The risk of VTE is particularly heightened following MOS, reaching up to 85%, and often presents with latent clinical manifestations, thus posing significant challenges in the prevention and management of post-MOS VTE [20, 21].

In this study, the doctor-to-patient cultivation of musculoskeletal ability, guided by King's theory of goal attainment, was employed to prevent and control VTE in post-MOS patients. Comparison between the musculoskeletal ability cultivation intervention and routine nursing management was conducted for the analysis of their potential clinical efficacy. In terms of MCIS scores, the observation group demonstrated a significant reduction post-intervention, which were notably lower than those of the regular group. This finding indicates that the doctor-to-patient cultivation of musculoskeletal ability, based on King's theory of goal attainment, contributes to mitigating lesions in the limbs of patients post-MOS. These benefits come from the innovative interventions that have shifted the therapeutic focus from conventional VTE diagnosis and treatment into strategies centered on VTE prevention and control. Targeted preventive measures that incorporated preoperative VTE risk grading, risk factor assessment and judgment were provided to post-MOS patients. This approach effectively contributes to balancing the musculoskeletal ability of patients [22, 23]. In coagulation function testing, the observation group exhibited a decrease in D-D levels and a significant increase in PT levels, both markedly lower and higher, respectively, compared to those in the regular group. This suggests that patients' coagulation function can be enhanced through significant D-D inhibition and PT increase under the intervention of doctor-to-patient cultivation of musculoskeletal ability based on King's theory of goal attainment. The post-interventional WOMAC scores for muscle pain, tissue stiffness and musculoskeletal function and the total WOMAC scores of patients in the observation group were significantly reduced and notably lower than those of patients in the regular group. This finding indicates that the doctor-to-patient cultivation of musculoskeletal ability based on King's theory of goal attainment is conducive to improving the musculoskeletal health of patients after MOS. This innovative intervention offers guidance and health education to patients on various ankle pump exercises, including dorsiflexion, plantar flexion, internal and external rotations, and isometric contraction skills of the gastrocnemius and quadriceps femoris, playing a crucial role in patients' awareness of diseases-related information and providing guidance on the early engagement in activities for maintaining musculoskeletal health [24, 25]. Prior research has highlighted the clinical effectiveness of early mobilization in preventing postoperative VTE, which can reduce hospitalization duration while minimizing adverse events such as muscle atrophy, tissue oxygenation damage, and VTE occurrence [26, 27].

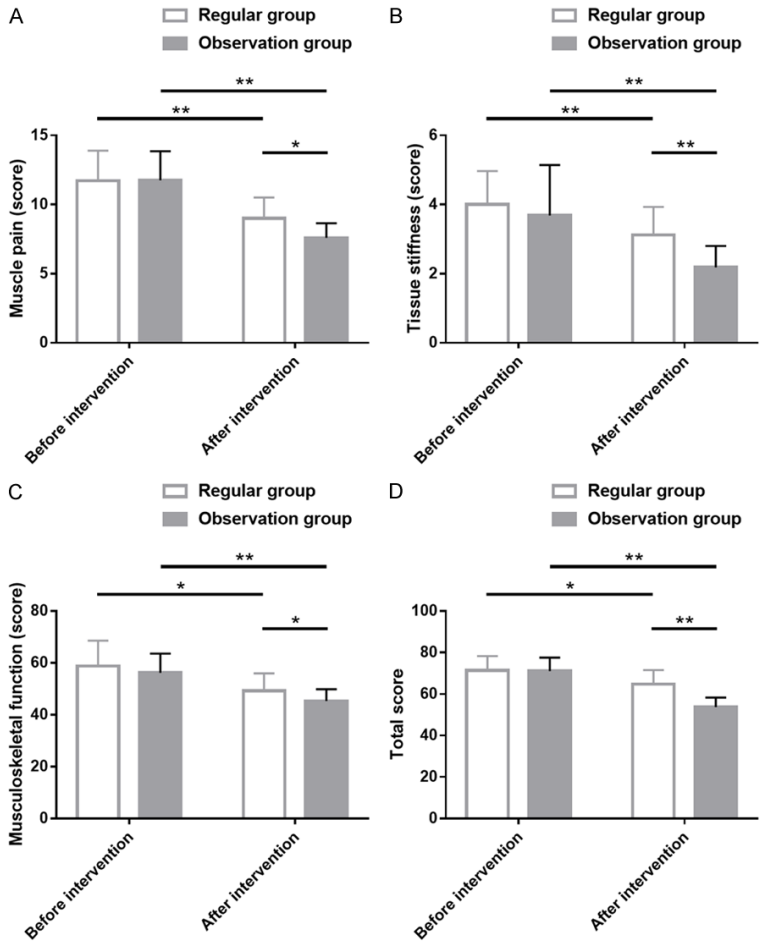

Figure 3. Comparison of WOMAC scores of muscle pain, tissue stiffness, musculoskeletal function, and the total WOMAC scores between the two groups before and after intervention. A. The muscle pain score was significantly higher in the observation group than that in the regular group. B. The tissue stiffness score was significantly higher in the observation group versus the regular group. C. The observation group had an obviously higher musculoskeletal function score than the regular group did. D. The total WOMAC score was significantly higher in the observation group versus the regular group. Note: WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index; * and ** represent $P < 0.05$ and $P < 0.01$, respectively.

Table 2. Comparison of VTE prevention effects between the two groups

Indicator	Regular group (n = 56)	Observation group (n = 60)	χ^2	P
DVT	4 (7.14)	1 (1.67)		
PTE	2 (3.57)	0 (0.00)		
VTE	6 (10.71)	1 (1.67)	4.182	0.041

Note: DVT: deep venous thrombosis; PTE: pulmonary thromboembolism; VTE: venous thromboembolism.

The analysis of the effectiveness of VTE prevention and control interventions revealed a markedly lower overall incidence of VTE in the observation group compared to that in the regular group (1.67% vs. 10.71%). This underscores the significantly superior anti-VTE effect of doctor-to-patient cultivation of musculoskeletal ability based on King's theory of goal attainment over routine nursing management in post-MOS patients, aligning with the findings of Chua et al. [28]. Assisting patients in enhancing their self-management and adaptability has been demonstrated to be pivotal in VTE prevention and control [29]. The ESCA scale results revealed a notable increase in the evaluation scores of health knowledge level, self-concept, self-responsibility, and self-care skills of patients in the observation group after the interventions. These scores were significantly higher than both the pre-interventional scores and those of patients in the regular group. This result suggests that the doctor-to-patient cultivation of musculoskeletal ability guided by King's theory of goal attainment has significantly enhanced the self-care ability of post-MOS patients. The satisfaction rate of patients in the observation group after intervention was 95.00%, which was higher than the 82.14% in the regular group, suggesting that the doctor-to-patient cultivation of musculoskeletal abilities on the basis of King's goal achievement theory has better effects than the conventional nursing interventions does in terms of VTE prevention and control in patients after MOS. In recent years, King's theory of goal attainment has emerged as a focal point in the

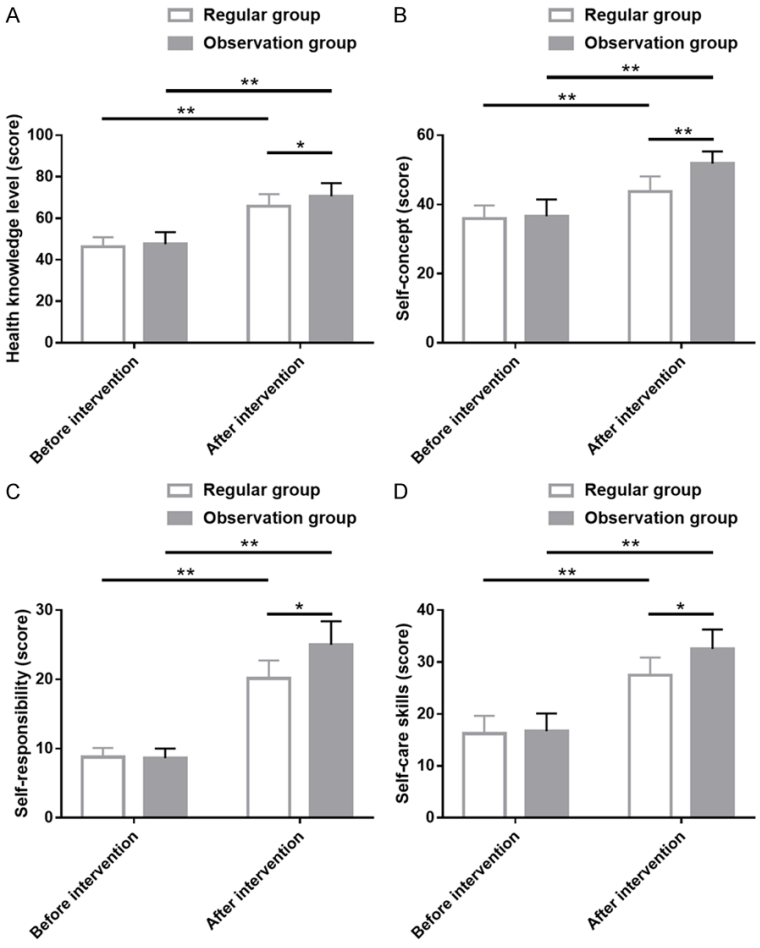

Figure 4. Comparison of ESCA scores of health knowledge level, self-concept, self-responsibility, and self-care skills between the two groups before and after intervention. A. The score of health knowledge level was significantly higher in the observation group. B. The self-concept score was markedly higher in the observation group. C. The self-responsibility score was obviously higher in the observation group. D. The score of self-care skills was statistically higher in the observation group. Note: ESCA: Exercise of Self-care Ability Scale; * and ** represent $P < 0.05$ and $P < 0.01$, respectively.

Table 3. Comparison of nursing satisfaction between the two groups

Indicator	Regular group (n = 56)	Observation group (n = 60)	χ^2	P
Very satisfied	20 (35.71)	34 (56.67)		
Moderately satisfied	26 (46.43)	23 (38.33)		
Not satisfied	10 (17.86)	3 (5.00)		
Total satisfaction	46 (82.14)	57 (95.00)	4.812	0.028

research on nursing interventions. It enhances the relationship between nurses and patients, fosters their empathy and realizes effective healthcare related education and guidance in patients. Cultivating musculoskeletal health proves beneficial in augmenting patients' awareness of disease related information, overall healthcare, and rehabilitation capacity. This study, to a certain extent, has elucidated the significant improvement on patients' self-care ability following orthopaedic surgery under the intervention of doctor-to-patient cultivation of musculoskeletal ability based on King's theory of goal attainment. Furthermore, research by Bloomfield HE et al. [30] noted that self-management helped reduce the risks associated with death and thromboembolic events, findings that are consistent with those of the present study.

Despite the significant findings, this study has several limitations: (1) Being a single-center study with a small sample, this study is susceptible to selection biases, and its statistical analysis strength may be limited. (2) Some indicators used to observe the treatment effects in this study are based on scale scores. Given the subjective nature of patients' self-assessment, there is a possibility of errors in these scores, which may affect the credibility of the observed treatment effects. (3) Limited research and observation time may yield outcomes that differ from those seen with long-term interventions in patients undergoing MOS. Their prolonged disease course and susceptibility to various factors during treatment make it challenging to accurately assess long-term outcome. Consequently, further prospective clinical studies are needed to confirm the conclusions drawn from this study.

In conclusion, doctor-to-patient cultivation of musculoskeletal ability, guided by King's theory of goal attainment, has significantly contributed to VTE prevention and control, as well as enhancing patients' self-care skills. Moreover, the proposed intervention has effectively reduced limb lesions, improved coagulation function, and enhanced musculoskeletal health of patients.

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Disclosure of conflict of interest

None.

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