

Original Article

Effectiveness of a Modified Knee Joint Functional Exercise Method Combined with a Goniometer in Patients After Joint Replacement Surgery

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Objective: To analyze the effectiveness of a modified knee joint functional exercise method combined with a goniometer in patients after joint replacement. **Methods:** Sixty patients who underwent orthopedic knee replacement were divided into two groups: a control group (n = 30, conventional intervention) and an intervention group (n = 30, modified knee functional exercise method combined with a goniometer). Postoperative knee function (Knee Society Score, KSS), compliance with functional exercises, and quality of life were evaluated and compared between the two groups. **Results:** Before the intervention, as well as two days post-operation and on the day of discharge, there were no significant differences in KSS scores between the two groups. However, at 2 weeks, 3 weeks, 1 month, 3 months, and 6 months post-operation, the intervention group showed significantly higher KSS scores compared to the control group ($P < 0.05$). The compliance rate of knee joint function exercise in the intervention group was significantly higher ($P < 0.05$). After intervention, the PF, GH, VT, and MH dimensions of quality-of-life scores in the intervention group were higher than those before intervention and higher than those in the control group ($P < 0.05$). **Conclusion:** The modified knee functional exercise method combined with an goniometer effectively improves knee function, enhances training compliance, and improves the quality of life in patients following joint replacement.

Keywords: Knee Arthroplasty, Knee Joint Goniometer, Knee Society Score, Modified Knee Joint Function Exercise Method

Introduction

With the rapid population growth in China, the country is facing an increasingly serious issue of population aging. This has led to a high prevalence of pathological changes in the knee joint and related diseases, which can impair motor function and pose significant threats to patients' physical and mental health, as well as their quality of life^{1,2}.

Total Knee Arthroplasty (TKA) is a surgical procedure that replaces damaged joint structures with biological or

non-biological prosthetic materials. It is the mainstream clinical treatment for knee degenerative diseases and has proven effective in treating end-stage knee joint conditions, correcting joint deformities, and improving joint function³.

Postoperative rehabilitation is crucial for TKA patients, requiring systemic functional exercises under the guidance of medical staff. However, the short hospitalization period after surgery often limits the time available for functional training, making it insufficient to meet patients' rehabilitation needs⁴⁻⁶. Therefore, strengthening out-of-hospital rehabilitation guidance is essential to ensure the success of surgical treatment, promote joint function recovery, and enhance patient outcomes⁷.

Rivière C et al.⁸ reviewed the home-based functional exercise guidance as a primary rehabilitation need for TKA patients. Based on this, the present study involved patients who underwent TKA in our hospital to explore the effectiveness of improved knee joint functional exercises combined with the goniometer. The aim was to provide a theoretical basis

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Table 1. Comparison of general data of patients between the two groups.

		Intervention group (n=30)	Control group (n=30)	Statistical value (t/x ²)	P value
Age (years, $\bar{x}\pm s$)		65.31±9.85	66.43±8.94	0.461	0.643
Occupation	On-the-job	17	19	0.783	0.676
	Retired	3	4		
	Unemployed	10	7		
Education level	Primary school and below	13	13	0.134	0.935
	Middle school	12	11		
	College degree or above	5	6		
Per capita monthly household income (yuan)	≤2000	15	12	0.6062	0.436
	>2000	15	18		
Religious beliefs	Yes	1	2	0.3512	0.554
	No	29	28		

for developing continuous functional exercise programs after joint replacement, enhance rehabilitation outcomes, and improve patients' quality of life.

Methods

Clinical Data

60 patients who underwent orthopedic knee arthroplasty at the Orthopedics Department of Changzhi People's Hospital between June 2022 and June 2023 were divided into two groups: a control group (n = 30, receiving conventional intervention) and an intervention group (n = 30, receiving a modified knee functional exercise method combined with a goniometer). A comparison of the baseline characteristics between the two groups revealed no statistically significant differences ($P > 0.05$), indicating comparability. Details are presented in Table 1.

Inclusion Criteria:

- ① Patients meeting the indications for TKA with no history of prior surgeries
- ② Aged 50–70 years
- ③ Patients with normal cognitive function

Exclusion Criteria:

- ① Patients with severe postoperative complications or loss of functional exercise ability
- ② Patients with cognitive or communication impairments, or other conditions preventing cooperation or survey completion.

Intervention method of intervention group

Formation of a professional medical intervention research team

Experienced nurses and orthopedic joint specialists participated in the study design, including four attending

physicians, four supervising nurses, and a medical team leader responsible for physical examinations and scoring to ensure data accuracy and authenticity. Data analysis and aggregation were conducted by a graduate nursing student.

Development of Standardized Training Program for Research Team Members

Standardized training was provided to participants, covering topics such as knee joint function exercises, use of a knee joint goniometer, sampling methods, KSS score evaluation and recording, completion of rehabilitation diaries, and discharge education, among others.

Establishment of a WeChat Group for Continuous Rehabilitation Training and Development of a Knee Rehabilitation Assessment Form

A WeChat group was created to support continuous rehabilitation training after knee replacement. Additionally, a summary table was developed to assess knee rehabilitation progress. Data on patients' rehabilitation exercises, both in-hospital and at home, were collected.

Intervention Group Intervention Protocol

The working principle of the knee joint goniometer is as follows:

1. The clamping plate (id-4) of the angle measuring tool was securely fixed using the clamping strips (id-8) on the side of the calf longboard (id-3). The calf longboard rotated around the screw (id-2), allowing the clamping plate to fold and store alongside the thigh longboard (id-1), effectively minimizing the tool's occupied space.
2. Anti-slip patterns were provided on the sides of the longboards (near the body), increasing the frictional contact area between the longboards and the patient's

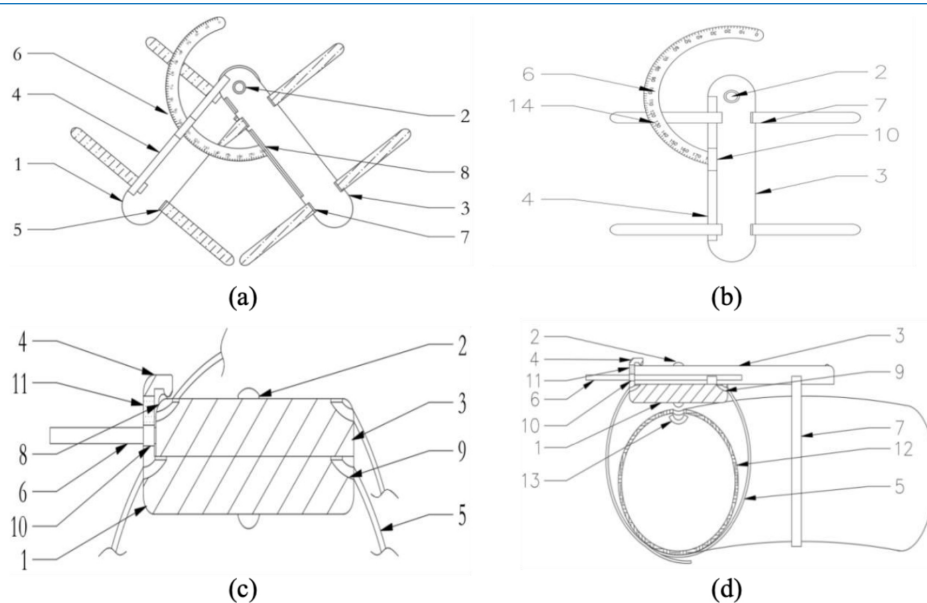


Figure 1. Working Principle of the Goniometer.

Table 2. Modified knee joint function exercise method.

Knee joint angle	$\leq 90^\circ$	$> 90^\circ$
Exercise Methods	Recumbent position, hug thighs, natural calf drooping method	Sitting position, hugging calf method

clothing. This helped prevent slippage or dislocation of the longboards when the legs were moved. The two longboards were connected and fixed using the screw, while the screw nest cap (id-13), positioned towards one end of the knee joint, aligned and adsorbed onto the screw. The screw nest cap could be placed inside the clothing at an appropriate thickness, allowing the clothing to be securely fixed and helping position the tool's midpoint.

- The strap bolt groove (id-9) acted as a replacement strap bolt notch, thereby extending the tool's service life.
- The thigh strap (id-5) and calf strap (id-7) were wrapped in an annular shape around the patient's trouser leg cloth (id-12). This ensured that the angle measuring tool remained securely in place, preventing it from falling off during use and allowing the patient to move freely.
- When the thigh longboard and calf longboard formed a predetermined angle, the upper scale (id-14) of the protractor (id-6) aligned with the corresponding reading sensor (id-11) within the through groove (id-10). The reading was displayed through the clamping plate, enabling automatic and accurate measurement of the

knee joint angle. This made the operation simple and convenient for the user. Note: Identification numbers, such as id-4 etc, correspond to equipment components as shown in Figure 1.

Intervention Plan for Postoperative Days 1-2

The modified knee joint function exercise method was used to guide the patient. The exercise duration was 5-10 minutes per session, performed twice daily. The exercise method was shown in Table 2. At the end of each session, the patient was instructed to distinguish the front and back sides of the goniometer, align the bearing part of the instrument with the midpoint of the knee joint, and secure the thigh and calf straps. The patient then slid the calf to move the measuring instrument, forming the knee joint angle. The angle measured at that time was recorded, and the medical team leader of the intervention group jointly scored the first postoperative KSS and documented it. The patient was informed of the results, and based on these initial findings, the target angle for knee joint exercise the following day was determined.

Intervention Plan for Postoperative Days 3-5

Postoperative days 3-5, the patient's ability to perform improved knee joint exercises and use the knee joint goniometer was assessed. A rehabilitation exercise diary was provided, with instructions on accurately recording knee joint angles. Doctors and nurses monitored daily exercises, developed targeted knee joint angle exercise plans based on the patient's condition, and provided necessary guidance and interventions.

Discharge Instructions

On the day of discharge, the medical team leader conducted the second KSS assessment to ensure the patient had mastered the functional exercise technique and the use of the knee goniometer. The patient was invited to join the WeChat intervention group, where they were guided to perform knee exercises on time after discharge and record their progress in the exercise diary. Every Sunday, the patient uploaded the completed knee exercise diary to the group, and the data were reviewed, evaluated, and analyzed to provide necessary guidance. Postoperative follow-up and KSS assessments were conducted at 2 weeks, 3 weeks, 1 month, 3 months, and 6 months after surgery. Additionally, a quality-of-life assessment was conducted at 6 months postoperatively.

Intervention Methods for the Control Group

In the control group, patients received routine intervention after knee arthroplasty, including routine TKA perioperative health education such as preoperative preparation, postoperative precautions, and functional exercises. After discharge, they were provided with routine discharge education and scheduled for timely follow-up examinations.

Evaluation Indicators

KSS Score

The Knee Society Score (KSS) was used to evaluate and compare the patients' knee function recovery at 1 day, 1 week, 2 weeks, 3 weeks, 1 month, 3 months, and 6 months post-operation. The scoring criteria were as follows:

- Excellent: 85-100 points
- Good: 70-84 points
- Fair: 60-69 points
- Poor: < 60 points

Knee function recovery was positively correlated with the score.

Functional Exercise Compliance

Two particular nurses were responsible for the evaluation and comparison of the patients' compliance with knee function exercises. The following categories were used:

- Complete compliance: No conflicting behavior during knee function exercises, with exercise 5-7 days a week.

- Partial compliance: Occasional conflicting behavior during knee function exercises, with exercise 3-5 days a week.
- Non-compliance: Serious conflicting behavior during knee function exercises, with exercise less than 3 days per week.

Total compliance = complete compliance + partial compliance.

Quality of Life Survey

The SF-36 quality of life questionnaire was used to evaluate the quality of life of patients before and 6 months after intervention. The scale consisted of 36 items across 8 dimensions:

- Physical Function (PF)
- Role Physical (RP)
- Bodily Pain (BP)
- General Health (GH)
- Vitality (VT)
- Social Function (SF)
- Role Emotional (RE)
- Mental Health (MH)

The total score for each dimension ranged from 0 to 100, with higher scores indicating better quality of life, and quality of life was positively correlated with the score.

Statistical Analysis

SPSS 26.0 was used for statistical analysis. Descriptive statistics were applied to the general data. For measurement data that followed a normal distribution, the mean \pm standard deviation was used, and a two-independent-sample t-test was employed for group comparisons. Count data were presented as frequency and percentage, and the chi-square (χ^2) test was used for group comparisons. A p-value of < 0.05 was considered statistically significant.

Results

Comparison of KSS Scores Between the Two Groups

Before intervention, two days after the operation, and on the day of discharge, there was no significant difference in KSS scores between the two groups ($P > 0.05$). At 2 weeks, 3 weeks, 1 month, 3 months, and 6 months post-operation, the KSS scores of the intervention group were significantly higher than those of the control group ($P < 0.05$) (Table 3).

Comparison of Functional Exercise Compliance Between the Two Groups

The compliance rate for knee joint function exercise in the intervention group was significantly higher than that in the control group (100% vs. 60%), with the difference being statistically significant ($P < 0.05$) (Table 4).

Table 3. Comparison of KSS scores between the two groups of patients ($\bar{x} \pm s$).

Group	Number of patients	Before intervention	2 days after operation	Day of discharge	2 weeks	3 weeks	1 month	3 months	6 months
Intervention group	30	60.48±8.95	60.52±8.76	61.88±9.01	66.73±7.62	69.51±8.12	70.15±9.24	76.94±8.76	82.35±9.39
Control group	30	59.98±7.91	60.31±8.44	61.02±9.30	61.93±8.01	63.09±7.65	63.98±9.42	66.29±8.17	70.11±8.76
<i>T</i>		0.23	0.09	0.36	2.38	3.15	2.56	4.87	5.22
<i>P</i>		0.82	0.92	0.72	0.02	0.002	0.01	<0.01	<0.01

Table 4. Comparative ratio of functional exercise compliance between the two groups of patients (%).

Group	Number of patients	Non-compliance	Partial compliance	Full compliance	Total compliance
Intervention group	30	0 (0)	5 (16.67)	25 (83.33)	30 (100)
Control group	30	12 (40)	14 (46.67)	4 (13.33)	18 (60)

Note: Comparison of knee joint function exercise compliance between the two groups: $\chi^2 = 31.47$, $P < 0.05$.

Table 5. Comparison of SF-36 scores between the two groups of patients ($\bar{x} \pm s$). Physical Function (PF), Role Physical (RP), Bodily Pain (BP), General Health (GH), Vitality (VT), Social Function (SF), Role Emotional (RE), Mental Health (MH).

Group	Number of patients	Time	PF	RP	BP	GH	VT	SF	RE	MH
Intervention group	30	Before intervention	55.13±5.94	54.24±25.65	47.46±16.88	41.91±17.87	49.13±7.44	50.87±22.26	51.53±30.18	50.34±8.57
		After intervention	70.18±7.01 ^{①②}	69.99±26.54 ^②	56.12±14.51 ^②	69.83±19.23 ^{①②}	65.1±8.23 ^{①②}	59.14±21.67 ^②	70.15±28.91 ^②	67.14±9.01 ^{①②}
Control group	30	Before intervention	57.55±6.54	53.40±22.89	45.16±19.25	39.64±18.71	50.28±6.91	52.09±21.17	53.21±29.46	51.49±7.96
		After intervention	64.29±4.88 ^②	60.72±27.11	53.37±16.43 ^②	58.64±20.30 ^②	57.92±7.26 ^②	57.61±20.82	66.13±30.03 ^②	60.22±8.91 ^②

Note: ^① $P < 0.05$: Comparison between the intervention group and the control group after intervention; ^② $P < 0.05$: Comparison between the intervention group and the control group before and after intervention.

Comparison of SF-36 scores Between the Two Groups

Before the intervention, there were no significant differences in the quality-of-life scores for PF, RP, BP, GH, VT, SF, RE, and MH between the two groups ($P > 0.05$). After the intervention, the quality-of-life scores in the intervention group were higher than before the intervention. Additionally, the scores for PF, GH, VT, and MH in the intervention group were significantly higher than those in the control group, with statistical significance ($P < 0.05$) (Table 5).

Discussion

Modified Knee Function Exercise Method Combined with Goniometer Can Improve Knee Function in Patients After TKA

Scientific and well-designed postoperative rehabilitation exercises are essential for promoting the recovery of knee joint function⁹. Research has shown that loss of lower limb strength and function is common within the first month after TKA, and early exercise plays a crucial role in the recovery of limb function¹⁰. The results of this study revealed that

the KSS scores of the intervention group were significantly higher than those of the control group at 2 weeks, 3 weeks, 1 month, 3 months, and 6 months post-operation ($P < 0.05$). The modified knee function exercise method combined with the goniometer is vital for the continuous rehabilitation of patients after TKA, effectively improving knee function. In the intervention group, the improved knee functional exercise method, along with a custom-designed knee goniometer, was implemented on the first day after TKA. Based on previous clinical experience, it was found that selecting the appropriate posture and targeted exercises based on the knee angle range helps improve the patient's proprioception, strengthen knee muscle strength, and enhance knee joint stability. Moreover, appropriate functional exercises and accurate knee angle measuring tools can improve the patient's subjective experience, reduce pain, and promote the recovery of knee joint mobility¹¹.

Modified Knee Joint Functional Exercise Method Combined with Goniometer Can Improve Functional Exercise Compliance in Patients After TKA

The results of this study showed that the compliance rate for knee functional exercise in the intervention group was significantly higher than in the control group ($P < 0.05$). The modified knee functional exercise method combined with the goniometer can significantly enhance functional exercise compliance in patients after TKA. This may be attributed to the advantages of postoperative knee functional exercises in pain management and the ease of using the goniometer in conjunction with functional exercises. Previous studies have indicated¹² that effective knee function exercises can promote local blood circulation, reduce inflammation, alleviate postoperative discomfort, and strengthen muscle support, thereby accelerating the recovery process. The instrument used in this study is easy to operate, providing patients with clear and specific values for their current exercise progress, which boosts their enthusiasm and compliance with functional exercise. It also provides a data basis for healthcare professionals to guide follow-up exercises. Furthermore, by establishing a WeChat group for continuous rehabilitation after TKA and creating a knee joint rehabilitation assessment summary table, this study facilitates tracking patients' training progress and rehabilitation outcomes. This enables timely evaluation of individual differences and adjustment of rehabilitation plans, positively influencing patients' adherence to rehabilitation training and improving their overall compliance.

Improved Knee Joint Function Exercise Method Combined with Goniometer Can Improve the Quality of Life of Patients After TKA

After the intervention, the quality-of-life scores for PF, RP, BP, GH, VT, SF, RE, and MH in the intervention

group were higher than those before the intervention. Additionally, the quality-of-life scores for PF, GH, VT, and MH were significantly higher in the intervention group compared to the control group ($P < 0.05$). The improved knee joint function exercise method combined with the goniometer can significantly enhance the quality of life for patients after TKA, which aligns with the findings of Canovas et al.¹³. Both domestic and international studies have shown^{14,15} that isometric, isotonic, isokinetic, and both active and passive exercise training can effectively reduce pain, improve knee joint stability, promote motor function recovery, and ultimately enhance patients' quality of life. With the data provided by the knee goniometer and the improved knee function exercise method, the intervention group in this study helped patients restore knee function to a normal level in a relatively short time, improve their self-care ability, alleviate psychological burdens and negative emotions, and support their reintegration into normal life. This approach had significant effects on maintaining both the physical and mental health of patients, ultimately improving their quality of life.

This study has limitations. It was conducted at a single tertiary hospital in Shanxi Province with a small sample size, and only 6 months of data were collected. To further validate the effectiveness and long-term impact of these interventions, future research should involve multi-center, large-sample longitudinal studies.

Conclusion

In conclusion, the knee joint goniometer is easy to operate and practical. The application of the improved knee joint functional exercise method combined with the goniometer effectively promotes the recovery of knee joint function after TKA, enhances patient compliance with functional exercise, and improves patients' quality of life.

Ethics approval

The study was approved by the Ethics Committee of The People's Hospital of Changzhi (approval number: 2022-03-17).

Consent to participate

All patients provided written informed consent prior to the study.

Authors' contributions

LZ designed the study and drafted the manuscript. YH and XH were responsible for the collection and analysis of the experimental data. LZ, YH, and XH critically revised the manuscript for important intellectual content. All authors read and approved the final version of the manuscript

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