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A retrospective study of rehabilitation for patients with hemophilia knee osteoarthritis after total knee arthroplasty: a 10 year cohort study

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Abstract

Objective Rehabilitation is an important means to help hemophilic arthropathy (HA) patients recover joint function after total knee arthroplasty (TKA). This article retrospectively analyzes the experience of rehabilitation therapy.

Methods We retrospectively analyzed cases from January 2011 to December 2021 in the Bone Injury Center Database of Zhejiang Provincial Hospital of Traditional Chinese Medicine. A total of 50 patients were included, classified according to preoperative range of motion (ROM): 14 with ROM between 0 and 45 degrees, 28 with ROM between 45 and 90 degrees, and 8 with ROM greater than 90 degrees. Recording knee joint function and complications from preoperative to postoperative 24 months.

Results Patients' knee joint function improved after rehabilitation. The clinical and functional Knee Society Score (KSS) of 0°-45° group increased from 91.36 ± 7.91 to 102.25 ± 5.75 ($P < 0.001$), 45°-90° group increased from 102.25 ± 5.75 to 126.64 ± 6.97 ($P < 0.001$), 45°-90° group increased from 104.13 ± 2.80 to 128.00 ± 3.16 ($P < 0.001$). ROM of 0°-45° group increased from 54.07 ± 8.44 to 77.86 ± 8.20 ($P < 0.001$), 45°-90° group increased from 77.75 ± 9.59 to 90.43 ± 5.07 ($P < 0.001$), 45°-90° group increased from 103.25 ± 5.28 to 109.00 ± 5.58 ($P < 0.001$), and Visual Analogue Scale (VAS) of 0°-45° group decreased from 5.36 ± 1.01 to 3.86 ± 0.86 ($P < 0.001$), 45°-90° group decreased from 5.07 ± 0.98 to 3.64 ± 0.95 ($P < 0.001$), 45°-90° group decreased from 5.38 ± 0.74 to 3.88 ± 0.64 ($P < 0.001$). In a subgroup analysis, the patients with higher preoperative ROM have higher postoperative ROM and KSS. At the end of follow-up, patients with low preoperative ROM had higher VAS scores than other patients.

Conclusion We recommend conducting a systematic evaluation and pre rehabilitation of patients before TKA surgery, and establishing their psychological expectations, followed by early initiation of postoperative rehabilitation.

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Furthermore, attention should be paid to psychological counseling for patients to enhance their awareness of autonomous rehabilitation. Additionally, monitoring clotting factor levels and promoting functional recovery of adjacent joints and soft tissues are also crucial aspects to consider.

Keywords Haemophilic arthropathy, Rehabilitation, Total knee arthroplasty, Knee function

Introduction

In Hemophilia patients, 80%–90% of bleeding occurs in the musculoskeletal system [1]. The pathogenesis is attributed to hemophilic synovitis caused by recurrent joint bleeding, followed by joint erosion, cartilage damage, and adjacent bone erosion [2]. Studies indicate that in severe hemophilia (1% of normal activity of factor VIII or IX), the frequency of joint bleeding episodes can be as high as 20–30 times per year [3]. Therefore, total knee arthroplasty (TKA) is considered the best option for treating late-stage hemophilic knee arthropathy [4]. Rehabilitation therapy after TKA plays a crucial role in restoring joint function, promoting absorption of muscle hematomas and joint hemarthrosis, maintaining muscle fiber length and strength, improving joint range of motion, enhancing proprioception, and improving coordination and balance abilities [5]. It is an important means to help hemophilic arthropathy (HA) patients recover joint function. In this regard, this article retrospectively analyzes the experience and concepts of rehabilitation therapy for HA patients after TKA.

Method

Study design

This study retrospectively analyzed cases from January 2011 to December 2021 in the database of the rehabilitation center, and has obtained the ethical approval from the ethics committee of the center. All patients had read and signed informed consent forms. Inclusion criteria were as follows: patients with end-stage hemophilic knee arthropathy, Modified Arnold–Hilgartner grading [6] level IV. Simultaneously, patients underwent unilateral TKA during one hospitalization. Patients who developed severe complications such as periprosthetic infection and periprosthetic fractures after TKA, patients who underwent joint revision after TKA, and patients who could not tolerate rehabilitation therapy due to various personal factors were excluded. Cases with inconsistent opinions were evaluated by a third author to determine inclusion. After screening, a total of 50 patients were included, classified according to preoperative range of motion (ROM): 14 cases with ROM between 0 and 45 degrees, 28 cases with ROM between 45 and 90 degrees, and 8 cases with ROM greater than 90 degrees. All patients were followed up for at least 2 years postoperatively, recording knee joint function and complications before and after rehabilitation therapy, at 12 months postoperatively, and at 24 months postoperatively, storing clinical data, X-rays, and other data for analysis.

Surgical technique

All patients are given prophylactic cefuroxime antibiotics 30 min before surgery and 3–5 days after surgery. All surgeries are performed in the laminar flow operating room by the same experienced surgical team and protected completely with tranexamic acid. Hemostatic bands are used on all patients until skin closure is complete. TKA is performed using standard surgical techniques, with a midline anterior incision through the medial side of the patella for full osteotomy, releasing the internal and external soft tissues and posterior joint capsule, and completely removing the synovium. Some patients have drainage tubes placed postoperatively, and all prostheses are fixed with antibiotic cement. We do not administer any medications for thrombosis prophylaxis. In the event of major bleeding during surgery, patients will receive immediate blood transfusions and other treatments.

Rehabilitation philosophy

Comprehensive joint function assessment

Evaluate the preoperative and postoperative conditions of the knee, hip, ankle joints, muscles such as quadriceps, hamstrings, gastrocnemius, gluteus maximus muscles, and skin around joints to provide comprehensive rehabilitation for patients. Targeted training is conducted for areas with poor function.

Psychological counseling

Communicate the importance of rehabilitation to patients, informing them that rehabilitation exercises should be conducted under the supervision of rehabilitation therapists and physicians to ensure safety and avoid joint bleeding. Simultaneously, motivate patients to actively participate in rehabilitation treatment through psychological counseling to enhance the effectiveness of rehabilitation.

Preoperative rehabilitation

Conduct pre-rehabilitation to familiarize patients with rehabilitation exercises, enhance muscle awareness, facilitate prompt initiation of rehabilitation postoperatively, and inform patients in advance about postoperative rehabilitation precautions to improve the safety of rehabilitation treatment.

Rehabilitation methods

Adequate coagulation factor protection

Rehabilitation exercises are performed within 30–60 min after the infusion of coagulation factors for patients, rather than the conventional 6 h. Engaging in rehabilitation exercises shortly after coagulation factor infusion ensures patients' coagulation factor levels and prevents joint bleeding caused by movement.

Guided patient self-rehabilitation

In addition to traditional rehabilitation methods, guide patients to actively sense and control the activation of muscles such as quadriceps, hamstrings, popliteus, semitendinosus, and semimembranosus muscle groups. Utilize the sensory perception of the healthy limb to help the affected limb establish new neural pathways and accelerate the restoration of joint's active control.

Overall rehabilitation

Patients with HA often experience involvement of multiple joints during disease progression, and deformities and functional deficiencies in the hip and ankle joints can also affect the knee joint, especially the hip joint. During treatment, patients are informed and guided to perceive the interrelation between muscles in different parts of the lower limbs, such as balance of power relationship among the sartorius, gluteus maximus, tensor fasciae latae, quadriceps, and gastrocnemius. Emphasize the importance of overall rehabilitation, and when necessary, provide targeted rehabilitation training for surrounding joints such as the hip.

Rehabilitation plan

Upon admission, patients undergo assessments of muscle strength, joint function and mobility, followed by pre-rehabilitation. Within 24 h postoperatively, under the guidance of a rehabilitation physician, evaluate joint condition again, including neurological function, wound condition, joint swelling, pain, muscle strength, range of joint motion, transfer ability, gait and activities of daily living (ADL) to formulate detailed functional training plans accordingly. From postoperative days 1 to 3, knee joint function training training is initiated to improve joint mobility, along with muscle strength training, including extension and flexion training, Auxiliary equipment and walking gait training and Functional training of adjacent joints. Gradually engage in weight-bearing training, meanwhile, from postoperative days 3 to 7, active-assistive joint movement exercises are performed gradually transitioning to active joint movement training. Resistance training can gradually commence from the first week postoperatively. All patients received the same rehabilitation treatment plan within their tolerance range, Table 1 shows the complete details and operations of the rehabilitation plan.

All treatments must be conducted under the guidance of a professional rehabilitation physician, and rehabilitation training should be initiated within 30–60 min after coagulation factor replacement therapy to ensure that the concentration of coagulation factors reaches its peak and is at least 80% above normal, 1–2 times a day. In case of joint bleeding, rehabilitation treatment should be stopped immediately, and the RICE method (rest, ice, compression, and elevation) [7] should be applied, managed by a specialized hematology team.

The patient was discharged after two weeks of inpatient rehabilitation, and continued to receive outpatient rehabilitation treatment twice a week for a total of three months after surgery. The preoperative evaluation and rehabilitation techniques are shown in Fig. 1.

Outcomes evaluation

Record patient data before surgery, before rehabilitation, after rehabilitation, 12 months after surgery, and 24 months after surgery. This includes recording any complications that occur in the patient, including periprosthetic fractures, suspected prosthesis loosening, infections, skin ulcers, and incision tension blisters. Visual Analog Scale (VAS) and ROM assessment were used to evaluate and record the improvement in pain and joint range of motion. Use the Knee Society Score (KSS) [8] to assess the knee joint function of patients [8].

Statistical analysis

The data analysis was conducted using SPSS 25.0 (IBM, Amonk, New York, USA). Among them, ROM, KSS, and VAS are continuous variables with normal or approximately normal distributions. Therefore, paired t-tests are used for comparison before and after, and analysis of variance is used for comparison between multiple groups; For non parametric variables, Mann Whitney U test is used, and Kruskal Wallis test is used for inter group comparisons. The comparison of categorical variables is conducted using chi square test, and Fisher's exact test is used if necessary. Descriptive statistics are presented in the form of mean and standard deviation, median (interquartile range), or frequency (percentage), depending on the situation. A p-value < 0.05 is considered statistically significant, and all tests are two tailed tests.

Results

Patient demographics

According to the inclusion and exclusion criteria, a total of 50 male patients with HA who underwent unilateral TKA were selected and included in this study. Among them, 28 cases involved the left knee and 22 cases involved the right knee, with a mean age of 37.96

Table 1 Postoperative standard exercise and rehabilitation details for total knee arthroplasty in the rehabilitation process of hospitalized patients

Rehabilitation plan
Knee joint function training:
Knee joint extension training (From 1 week before surgery to 1 month after surgery):
1.Relax the techniques of the biceps femoris, geese foot tendon, gastrocnemius, and popliteus muscles behind the knee joint.
2.Knee joint extension technique is used to separate the joint surface, with each session lasting 40–60 s, repeated 3–5 times.
3.Passive knee extension range of motion training.
4.The isometric contraction of the quadriceps, gluteus maximus, and adductor muscles is maintained for 5–10 s and gradually increases.
5.Straight leg lift training.
Knee flexion (patient sitting position, From 1 week before surgery to 1 month after surgery):
1.Relaxation of thigh fascia technique and quadriceps technique to improve initial length.
2.Gently bend the knee joint to 20 degrees, and passively slide the knee joint in the anterior posterior direction of the tibia
3.Knee flexion gradually increases the flexion angle until pain is felt.
4.The patient's knee joint flexes in an active and painless state.
Auxiliary equipment and walking gait training (Trained with the assistance of a therapist within 6 weeks after surgery):
1.Use a walking aid or bilateral armpit crutches for weight bearing and standing balance training.
2.Gradually engage in weight-bearing training, using a walking aid or armpit crutch to achieve 50% of the weight within 3 days, and conducting center of gravity transfer training before and after 3 to 7 days, transitioning to 70% of the weight, and complete weight-bearing for 2 to 3 weeks.
3.Use a walking aid to exercise bilateral axillary crutches for gait training and correct poor posture.
4.Train up and down stairs. Within 6 weeks, the Healthy leg should rise first and the affected leg should fall first. After 6 weeks, the surgical leg can be trained to ascend and descend stairs normally under the guidance of a therapist.
Functional training of adjacent joints:
Ankle joint (From 1 week before surgery to 1 month after surgery):
1.Accurate stretching of ankle muscles and stretching of ankle Ligaments every 30s.
2.Therapists use dynamic joint mobilization techniques to improve ankle flexion and extension, as well as the range of motion of the medial and lateral flexion joints. Based on the specific condition of the patient's ankle joint, they try to release the ankle joint as much as possible in the early postoperative period to achieve 30 ° inversion, 15 ° eversion, 20 ° dorsiflexion, and 40 ° plantarflexion.
3.Guide patients to actively engage in ankle joint (resistance or non resistance) movements.
Hip joint (From 1 week before surgery to 1 month after surgery):
1.The therapist relaxes the fascia around the hip joint, precisely stretches the muscles around the hip, and relaxes the sacroiliac joint technique.
2.Therapists use dynamic joint mobilization techniques to improve hip joint flexion, extension, adduction, abduction, and rotational joint range of motion. In the early postoperative period, based on the specific condition of the patient's hip joint, they try to release it to 90 ° flexion, 20 ° adduction, and 30 ° abduction. In the long-term rehabilitation after discharge in January, it can be relieved to 110–120 °.
3.Guide patients to actively engage in hip joint (resistance or non resistance) movements.
Precautions and principles for rehabilitation treatment of hemophilia patients:
Rehabilitation training principles:
1.Patients actively participate, treatment plans vary from person to person, and the treatment process is gradual. Treatment requires patients to persevere.
Special precautions:
1.Coagulation factors should be used according to physician guidance
2.Full process monitoring and guidance for rehabilitation therapy by therapists
3.The training process follows the principle of painlessness
4.Scientific and reasonable treatment methods to avoid further damage
5.The overall principle is that hemophilia patients generally have multiple joint dysfunction and require overall evaluation and systematic treatment

years (± 9.23 years), body mass index (BMI) of 22.89 kg/m^2 (± 3.49), and average duration of illness of 28.64 years (± 10.40). Among the patients, there were 44 cases (88.00%) of Hemophilia A and 6 cases (12.00%) of hemophilia B. Thirteen cases (26.00%) were classified as mild (factor VIII activity: 5–40%), 21 cases (42.00%) as moderate (factor VIII activity: 1–5%), and 16 cases (32.00%) as severe (factor VIII activity < 1%). Ten patients (20.00%) were infected with hepatitis B virus (HBV), 26 patients (52.00%) with hepatitis C virus (HCV), and 10 patients (20.00%) with human immunodeficiency virus (HIV). There were no significant differences among the groups in terms of age, BMI, length of hospital stay, average duration of illness, type and severity of hemophilia, and underlying comorbidities ($P > 0.05$) (Table 2).

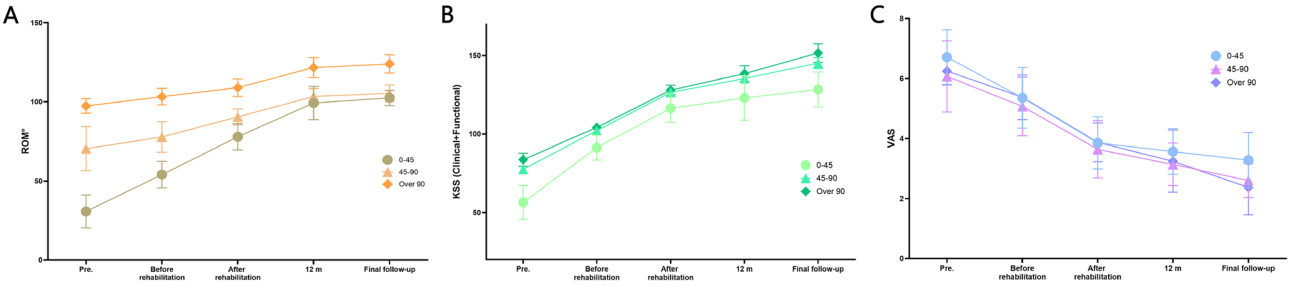

Fig. 1 Trends in the ROM, KSS (clinical and functional) and VAS, with the results obtained preoperatively, before and after rehabilitation, 12 month and final follow-up (**A**) ROM; (**B**) KSS (clinical and functional); (**C**)VAS. *ROM* range of motion, *KSS* Knee Society Score, *VAS* visual analogue scale, *Pre.* Preoperative

Table 2 Patient demographics and complication rates in each group

Variable	Total *n* = 50	Classification by ROM° *n* (%)/Mean ± SD			*P* velue
		0–45 (*n* = 14)	45–90 (*n* = 28)	>90 (*n* = 8)	
Age	37.96 ± 9.23	41.00 ± 8.37	36.11 ± 9.07	39.13 ± 10.72	0.254
BMI	22.89 ± 3.49	22.77 ± 2.35	23.23 ± 3.78	21.90 ± 4.24	0.637
Years of illness	28.64 ± 10.40	27.93 ± 10.92	27.46 ± 10.27	34.00 ± 9.41	0.285
Type of haemophilia					
Haemophilia A	44(88.00)	11(78.57)	26(92.86)	7(87.50)	0.413
Haemophilia B	6(12.00)	3(21.43)	2(7.14)	1(12.50)	0.413
Severity of haemophilia					
Mild	13(26.00)	3(21.43)	7(25.00)	3(37.50)	0.704
Moderate	21(42.00)	6(42.86)	13(46.43)	2(25.00)	0.561
Severe	16(32.00)	5(35.71)	8(28.57)	3(37.50)	0.842
Baseline comorbidity					
HBV	10(20.00)	2(14.29)	4(28.57)	4(28.57)	0.216
HCV	26(52.00)	10(71.43)	12(42.85)	4(50.00)	0.083
HIV	10(20.00)	2(14.29)	4(28.57)	4(28.57)	0.216

BMI Body mass index, *HCV* Hepatitis C virus, *HBV* Hepatitis B virus, *HIV* Human immunodeficiency virus

Table 3 Patient indicators for various categories before and after rehabilitation

Variable	Classified according to preoperative ROM			*P* velue
	0°–45°(*n* = 14)	45°–90°(*n* = 28)	>90°(*n* = 8)	
ROM° before rehabilitation	54.07 ± 8.44	77.75 ± 9.59	103.25 ± 5.28	0.000
ROM° after rehabilitation	77.86 ± 8.20	90.43 ± 5.07	109.00 ± 5.58	0.000
	0.000	0.000	0.000	
KSS before rehabilitation	91.36 ± 7.91	102.25 ± 5.75	104.13 ± 2.80	0.000
KSS after rehabilitation	116.43 ± 9.09	126.64 ± 6.97	128.00 ± 3.16	0.000
	0.000	0.000	0.000	
VAS before rehabilitation	5.36 ± 1.01	5.07 ± 0.98	5.38 ± 0.74	0.566
VAS after rehabilitation	3.86 ± 0.86	3.64 ± 0.95	3.88 ± 0.64	0.684
	0.000	0.000	0.000	

KSS Knee society score, *ROM* Range of motion, *VAS* Visual analogue scale

Knee joint function

As shown in Table 3, patients' knee joint function improved after rehabilitation treatment. The KSS (Clinical and Functional) of 0°–45° group increased from 91.36 ± 7.91 to 102.25 ± 5.75 ($P < 0.001$), 45°–90° group increased from 102.25 ± 5.75 to 126.64 ± 6.97 ($P < 0.001$), 45°–90° group increased from 104.13 ± 2.80 to 128.00 ± 3.16 ($P < 0.001$). ROM of 0°–45° group increased from 54.07 ± 8.44 to 77.86 ± 8.20 ($P < 0.001$), 45°–90° group increased from 77.75 ± 9.59 to 90.43 ± 5.07 ($P < 0.001$), 45°–90° group increased from 103.25 ± 5.28 to 109.00 ± 5.58 ($P < 0.001$), and VAS of 0°–45° group decreased from 5.36 ± 1.01 to 3.86 ± 0.86 ($P < 0.001$), 45°–90° group decreased from 5.07 ± 0.98 to 3.64 ± 0.95 ($P < 0.001$), 45°–90° group decreased from 5.38 ± 0.74 to 3.88 ± 0.64 ($P < 0.001$). Patients in each group showed a generally upward trend in KSS and ROM and a downward trend in VAS within two years (Fig. 2). In the

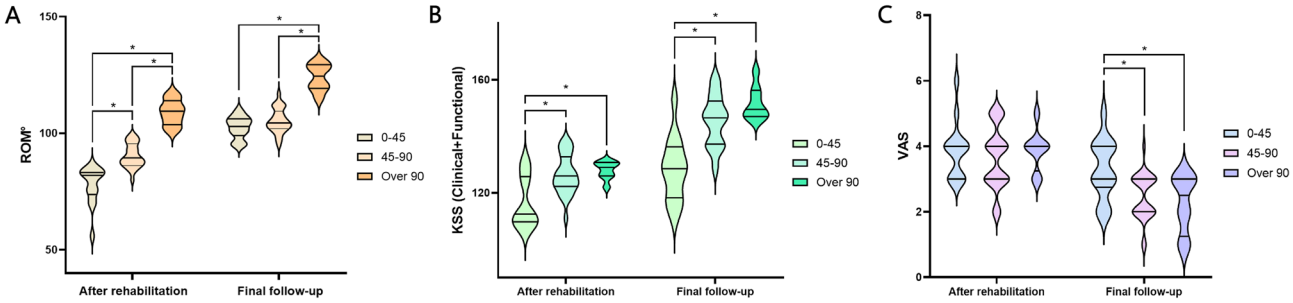

Fig. 2 Joint function at the end of rehabilitation and follow-up of patients with different ROM before surgery (**A**) ROM; (**B**) KSS (clinical and functional); (**C**)VAS. *ROM* range of motion, *KSS* Knee Society Score, *VAS* visual analogue scale

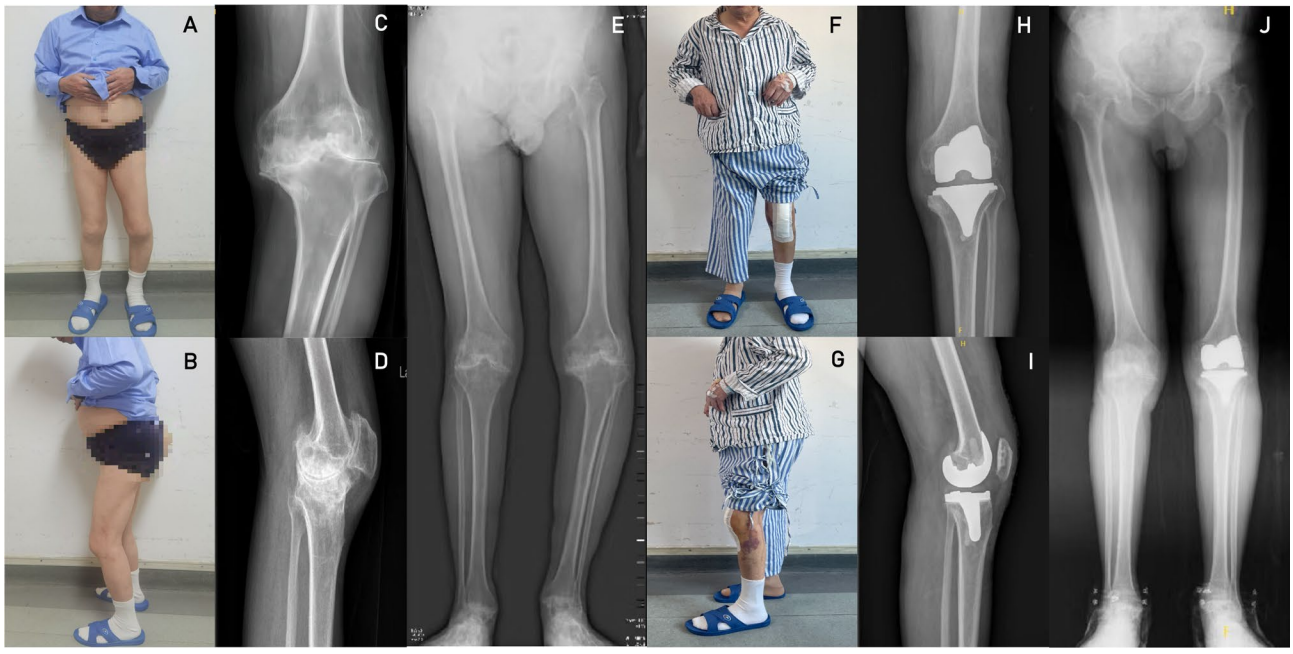

Fig. 3 A male patient with advanced haemophilic knee arthropathy. The preoperative (**A**) Clinical anterior views; (**B**) Clinical lateral view (**C**) Anteroposterior radiograph; (**D**) Lateral radiograph; (**E**) Long-leg standing radiograph. The postoperative (**F**) Clinical anterior views; (**G**) Clinical lateral view (**H**) Anteroposterior radiograph; (**I**) Lateral radiograph; (**J**) Long-leg standing radiograph

subgroup analysis, as shown in Fig. 3A, there were significant differences in ROM among the three groups after rehabilitation, with the lowest ROM observed in patients with preoperative ROM of 0–45 degrees and the highest ROM in patients with preoperative ROM greater than 90 degrees. At 24 months postoperatively, patients with preoperative ROM greater than 90 degrees had higher ROM than the other two groups ($P < 0.05$). Patients with preoperative ROM of 0–45 degrees had significantly lower KSS scores after rehabilitation and at the end of follow-up compared to the other two groups ($P < 0.05$) (Fig. 3B). Regarding VAS postoperatively, there were no significant differences among the groups at the end of rehabilitation. Patients with preoperative ROM of 0–45 degrees had significantly higher VAS scores than patients in the other two groups ($P < 0.05$) (Fig. 3C). A typical cases are shown in Fig. 4.

Complications

In the cohort of 50 patients in this study, a total of 8 complications occurred (16.00%). These included 1 case of periprosthetic fracture (PPF) occurring 12 months postoperatively due to a fall at home. The patient's knee joint function remains acceptable after revision surgery. Based on imaging examinations, 3 patients were suspected of prosthetic loosening. However, after appropriate rehabilitation exercises and administration of anti-osteoporosis and calcium supplementation drugs, no significant signs of loosening were detected at the last examination. Two patients developed skin ulcers, while two others developed tension blisters. After meticulous postoperative management and repeated treatments, the conditions of all three patients improved. Regarding patient satisfaction, only one case (2.00%) expressed disappointment due to the occurrence of PPF postoperatively, but they

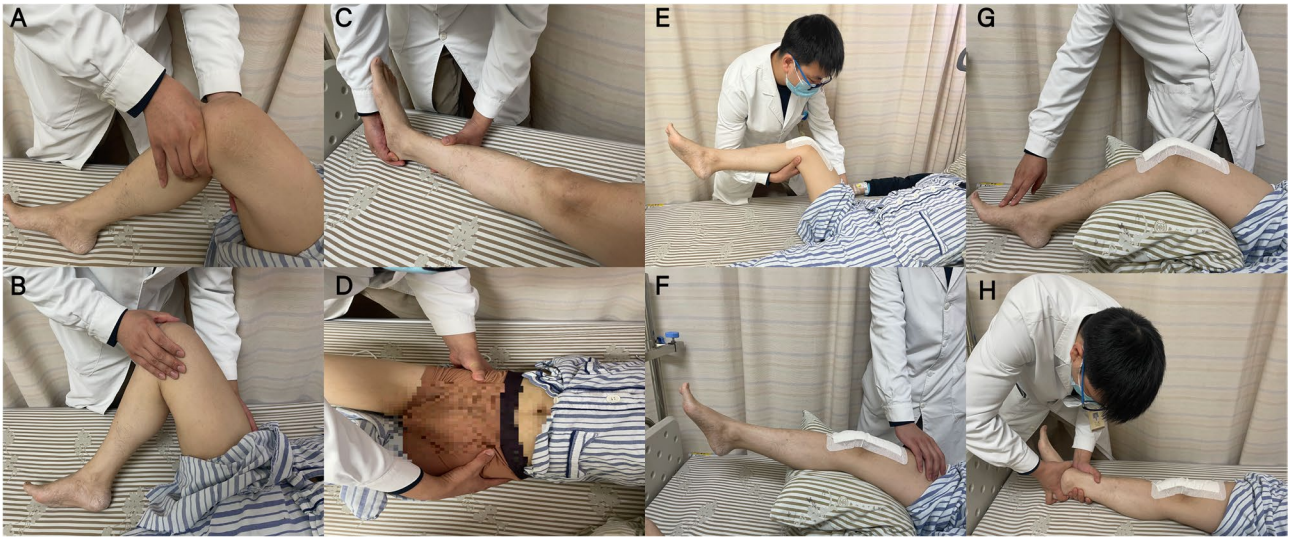

Fig. 4 **A** Preoperative knee joint assessment; (**B**) Preoperative muscle assessment; (**C**) Preoperative ankle joint assessment; (**D**) Preoperative hip joint assessment. Manual rehabilitation training (**E**) Knee joint function training; (**F**) Quadriceps muscle strength training; (**G**) Ankle back extension training; (**H**) Lower limb muscle stretching techniques

Table 4 Postoperative complications

Variable	
Complications	16%
Periprosthetic Fractures	1/2.0%
Suspicious Prosthetic loosening	3/6.0%
Infection	0/0.0%
Skin ulceration	2/4.0%
Tension blisters of incision	2/4.0%
Satisfaction	50/100.0%
Very satisfed	36/72.0%
Satisfed	13/26.0%
Disappointed	1/2.0%
Dissatisfed	0/0.0%
Neutral	0/0.0%

were satisfied with the surgical and rehabilitation outcomes. The remaining patients were satisfied with both the surgery and rehabilitation treatment (Table 4).

Discussion

For HA patients after TKA surgery, it is widely believed in the academic community that a suitable and good rehabilitation training is crucial for patients to recover joint function. Research by T.Viliani [12] has shown that postoperative rehabilitation positively affects ROM recovery in HA patients undergoing TKA and can positively influence patients' subjective evaluation of their quality of life. Studies by De Kleijn [13] and others emphasize the effectiveness and safety of physical rehabilitation for hemophilia patients after TKA. The importance of physical therapy in hemophilic knee joint disease is now fully recognized [14, 15].

In our cohort, patients' knee joint function improved after rehabilitation treatment, with increased Clinical and Functional KSS and ROM, and decreased VAS. Subgroup analysis showed that patients with higher preoperative ROM had higher ROM levels after rehabilitation and at follow-up. The repeated intra-articular bleeding and swelling in HA patients lead to intra-articular hematoma adhesions and fibrosis, which are significant reasons for preoperative ROM loss [16–18]. Current clinical studies widely recognize a significant correlation between preoperative joint deformity angles and postoperative joint angles in hemophilic patients [19, 20]. In study of Defalque [21], The maximum postoperative flexion ranges from 90 degrees for knee joints with preoperative flexion < 50 degrees to 100–130 degrees for knee joints with preoperative flexion > 65 degrees. Radovan et al. [22] data analysis shows that even after joint replacement surgery, Hemophilia patients with flexion contracture deformities exceeding 22.5 degrees still have residual flexion deformities exceeding 15 degrees, which affects the recovery of knee joint function after surgery. In terms of functional recovery, patients with lower preoperative ROM had lower KSS after rehabilitation and at follow-up compared to other patients. Additionally, while rehabilitation showed no significant difference in pain relief among hemophilic knee arthropathy patients with different preoperative ROM, patients with lower preoperative ROM experienced longer durations of pain at follow-up, possibly due to severe long-term joint deformities and soft tissue contractures. Furthermore, irregular prophylaxis with clotting factors post-discharge may exacerbate joint pain in some patients.

There were three suspected cases of loosening of the prosthesis in our cohort, which were alleviated after appropriate intensity of rehabilitation training and supplementation with bone density medication. Prosthesis loosening may be due to factors such as soft tissue imbalance and poor bone condition [23, 24]. For non-hemophilic individuals, the incidence of aseptic loosening after initial TKA ranges from 1 to 23%, and this figure may be higher in HA patients [25, 26]. Additionally, there were two cases of skin ulcers and two cases of tension blisters, but these conditions ultimately healed under careful nursing. Preoperative rehabilitation assessment of the patient's skin and soft tissue is crucial, as HA patients often face difficulties in wound healing due to bleeding edges, high wound tension, and poor soft tissue condition [27] and in the early postoperative period, a moderately intensive rehabilitation training plan should be developed based on the patient's incision condition.

A cochrane review of 17 studies involving 2562 patients indicated that pre-rehabilitation can alleviate postoperative pain and improve overall function in TKA patients [28]. Preoperative rehabilitation is crucial for patients' postoperative recovery, but there is less emphasis on preoperative rehabilitation for HA patients in existing research. Therefore, our study was the first to focus on the topic of preoperative rehabilitation for patients with HA, sharing experiences in rehabilitation plans. In our cohort, all patients underwent systematic assessment and pre-rehabilitation to familiarize themselves with the rehabilitation program and process, enhancing their cooperation and psychological preparation for postoperative limb function recovery training. This approach also included psychological counseling to increase patients' initiative and compliance. Some patients may miss the optimal period for postoperative functional recovery due to poor compliance caused by negative emotions such as pain and anxiety. However, proactive participation in pre-rehabilitation training before surgery could potentially address this issue [29]. Additionally, CPM training was initiated on the first day after surgery, as it can effectively improve joint mobility and reduce periarticular swelling in the initial postoperative period [30]. Patients with end-stage hemophilic knee arthropathy often have joint fibrosis, which hinders quadriceps contraction and affects patellofemoral joint movement [31]. therefore, early initiation of CPM is recommended postoperatively. Hemophilia patients after TKA have complex conditions and much higher complications than other types of patients [27], physical therapy, including active, passive, stretching, and weight-bearing exercises, should generally commence within 6 h after clotting factor replacement therapy to minimize bleeding risks [32, 33]. However pharmacokinetic studies of clotting factors show that peak levels typically occur within 60 min after injection [34]. Therefore, we recommend Conduct rehabilitation exercises within 30–60 min after clotting factor infusion, with ice application for 10–15 min after each session to reduce swelling and pain and lower bleeding risks [35]. Maintaining higher levels of clotting factors during rehabilitation not only enhances safety but also reduces patients' psychological burden and improves rehabilitation outcomes. Moreover, comprehensive rehabilitation of the hip and ankle joints is essential to adjust the force distribution of the lower limbs and restore walking function at the whole limb level. Physiotherapist should assess the patient's overall functional status, muscle, and joint conditions and develop a plan to prepare for the rehabilitation of adjacent muscles and joints [36, 37]. Hemophilia patients are generally able to actively participate in strengthening programs due to their youthfulness, high motivation, and lack of cognitive impairments [12], During the rehabilitation process, patients have a stronger sense of self-directed rehabilitation compared to elderly patients, and communication with rehabilitation therapists is also easier. Therefore, for patients with HA, preoperative rehabilitation and sufficient communication are necessary, Encouraging patients to engage in autonomous perception and movement under protection, utilizing muscle contraction sensations from the healthy limb to help establish neural pathways on the affected side and restore muscle control, can lead to better rehabilitation outcomes from a psychological perspective.

Study limitations

At present, research on the rehabilitation of hemophilia knee joint disease patients after TKA is limited. Our study shares the experience of single center hemophilia TKA rehabilitation, providing insights for clinical treatment in this field. However, our article has some limitations. Firstly, it is a retrospective study, inevitably subject to selection and analysis bias. In addition, hemophilia is a rare disease, and the sample size included in this study is relatively small, and no further correlation analysis has been conducted, which may lead to insufficient reliability of the analysis results, especially the incidence of complications. Future prospective studies with larger sample sizes and more center involvement are needed to verify the accuracy of rehabilitation outcomes.

Conclusion

In our cohort study, the effectiveness of rehabilitation in hemophilic knee arthropathy patients after TKA surgery is evident. Additionally, patients with higher preoperative ROM tend to have better postoperative mobility and knee joint function. We recommend conducting a systematic evaluation and pre rehabilitation of patients before TKA surgery, and establishing their psychological expectations, followed by early initiation of postoperative

rehabilitation. Furthermore, attention should be paid to psychological counseling for patients to enhance their awareness of autonomous rehabilitation. Additionally, monitoring clotting factor levels and promoting functional recovery of adjacent joints and soft tissues during rehabilitation are also crucial aspects to consider.

Abbreviations

HA	Hemophilic arthropathy
TKA	Total knee arthroplasty
ROM	Range of motion
VAS	Visual Analogue Scale
KSS	Knee Society Score
ADL	Activities of daily living
CPM	Continuous Passive Motion
BMI	Body mass index
HBV	Hepatitis B virus
HCV	Hepatitis C virus
HIV	Human immunodeficiency virus

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Authors' contributions
We would like to thank ZJ, YT, KY, TM, HH, ZZ, XH, PT, FP and SL. for all made important contributions to the study. ZJ, YT, KY, PT, FP and SL is responsible for the overall writing and conceptualization of the article. ZJ, YT, KY, TM collected and analysed the data. HH, ZZ and XH were responsible for data visualization. PT, FP and SL are responsible for guiding and revising the article. All the authors proofread and approved the final manuscript. All authors wrote, reviewed and edited the original draft and approved the final submitted version. Each author agreed to the statement here for their own contributions. ZJ, YT and KY contributed equally to this work.

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Data availability
The datasets used during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Consent for publication
The authors declare that they agree to publish. All patients provided written informed consent for their personal or clinical details, as well as any identification images published in this study.

Competing interests
The authors declare no competing interests.

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