Treatment and Rehabilitation of Knee Joints Straight Stiffness After Burns

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Abstract The knee release surgery and postoperative rehabilitation of patients after burns and knee straight stiffness were investigated. Eleven patients were treated for 16 side burns and knee stiffness who consisted of nine males and two females, aged 19 to 54 years (mean=33.2). The duration of the patients' knee stiffness ranged from 8 to 26 months, with an average of 12.6 months. Their preoperative flexion ranged from 5° to 50°, with an average of 26.2°. Their preoperative Hospital for Special Surgery (HSS) knee scores ranged from 46 to 72 points, with an average of 55.8 points. All stiff knees were treated with release surgery, along with total release of intra-articular adhesion and excision of vastus intermedius. After the arthrolysis of the stiff knee joint, the tight skin was completely loose in the adhesions. The soft tissue contracture was not grafted, but the shade fascia was freed to increase skin ductility. All knee joints were released to more than 90° of flexion in the operation, and reversed fascia flaps were used to suture the loss of the deep fascia at the position of flexion of 90°. After the operation, the knee joint was fixed in flexion for 72 h while being actively cared for by early rehabilitation. Subsequently, the patient's skin coverage, joint motion, and joint function recovery were observed. Based on the follow-up of the patients for the following 16 to 36 months (mean=25.7), the knee flexion of the patients ranged from 110° to

135°, with an average of 122.2° and 96° increase ($P<0.01$). Furthermore, the patients had better skin ductility to meet the increase in joint flexion. HSS knee function scores at the end of follow-up ranged from 93 to 100 points, with an average of 97.5 points and an increase of 41.7 points ($P<0.01$). The joint function improved significantly. The arthrolysis of straight stiff knee joints after burns can ease muscle contracture and free the shade fascia, thus avoiding the need to undergo skin grafting. Short-term fixation of the joints after surgery and active flexion rehabilitation may also be the key to improve skin ductility and joint function of the patients.

Keywords Knee stiffness · Straight stiff · Arthrolysis · Fixed flexion · Early rehabilitation

Introduction

Joint stiffness is one of the most common complications of burns, resulting in the decline of joint function and the inconvenience of the patient's daily life [1]. As seen in supine body burns and wound treatments, neglected rehabilitation, or the inability to carry out the training of joint activity, the knee joint is often associated with the stiffness after burns and usually in a straight type. Treatment methods vary according to the extent and duration of knee stiffness after burns. Some early or less severe cases of stiffness in patients can be addressed through the rehabilitation or a combination of brace treatment [2, 3]. However, patients who suffer from prolonged stiffness cannot be helped by simple rehabilitation alone. They often need knee release surgery to restore the range of motion and improve knee function. The treatment of the skin is very tricky in knee release surgery because of varying degrees of scar contracture. Most surgeons adopt skin grafting to solve the shortage of skin during the joint release surgery [4–7]. However, its disadvantages are clear, such as limited donor and new intra-articular

This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of the First Affiliated Hospital of PLA General Hospital. Written informed consent was obtained from all participants.

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adhesions by breaks in the skin graft. The question remains whether using a part of the burned patient's skin can improve skin tension and scalability by undergoing passive drafting surgery and postoperative active rehabilitation. In this report, the knee release surgery that leads to the incision of stiff skin contractures, skin treatment that frees the shade fascia, short-term postoperative fixation in flexion, and positive postoperative rehabilitation and flexion draft to improve skin ductility have positive results. Clinical results of the application of surgical release and postoperative rehabilitation on burned knee straight stiffness are discussed in this report.

Subjects and Methods

From June 2007 to December 2011, 11 patients were treated for 16 side burns and knee stiffness. The patients consisted of nine males and two females, aged from 19 to 54 years (mean=33.2). The type of injury was flame burn. Their burns around the knee joint were in deep II°, and the burn wound had healed. The duration of their knee stiffness ranged from 8 to 26 months, with an average of 12.6 months. Their preoperative flexion ranged from 5° to 50°, with an average of $26.2 \pm 11.9^\circ$. There was significant dysfunction in all of the patients' knee flexion (Fig. 1a, b). The joint function was assessed according to the Hospital for Special Surgery (HSS) rating scale [8] (Table 1). The preoperative scores ranged from 46 to 72 points, with an average of 55.8 ± 6.9 points. There were four cases with formation of ectopic bone around the knee before the operation.

Procedure

A longitudinal incision was made on the outside of the top of the knee to cut the skin, subcutaneous tissue, and joint capsule. Intra-articular adhesive strips were separated directly with the wrapped saline gauze in the joint cavity. White dense fibrous connective tissue among the vastus intermedius muscle between the rectus femoris and vastus laterals was turned (Fig. 1c). The fibrotic vastus intermedius muscle showed noticeable tension in the passive knee flexion, which affected the increase in knee flexion. There was a significant increase in passive flexion when the vastus intermedius muscular fibrosis was rampantly cut after complete separation. All knee joints could be released to more than 90° of flexion. However, a scarring of skin tissue could be visibly found white in flexion, which affected the increase of the said flexion. The heterotypic bones which would decrease the joint function of the patients were excised. There was no extension of the quadriceps tendons because no noticeable rectus femoris contracture was observed in all the patients. The skin grafting was not done for the tight skin. Instead, only free release between the deep and superficial fascias was done to increase skin laxity and scalability. After thorough flexion, the catheter drainage lysis was implemented and reversed fascia flaps were used to suture

the loss of the deep fascia at the position of flexion of 90°. The subcutaneous tissue and skin were primarily sutured followed by external plaster fixation in flexion. A good flexion fixed angle was determined to prevent postoperative skin necrosis (i.e., the prepatellar skin was not in a pale ischemic state).

Postoperative Treatment

Patient-controlled analgesia pumps were installed. The patients were encouraged to take isometric contraction training for their plastered limb muscles on the very next day after surgery. The 24 h drainage was implemented. If the drainage volumes were less than 50 ml, the tubes were removed. The fixed flexion plaster was removed 72 h after surgery. Essential active and passive training with the rehabilitation therapists were done every day in order for the patients to increase their range of motion as soon as the outside fixation was removed. The same procedures were done to the knee extension and the strengthening of flexion muscle. Suture removal followed 2 to 3 weeks later.

Postoperative Rehabilitation

Isometric muscle contraction exercises were performed within 72 h, while the patients were still in plaster. The knee muscle contraction training was especially important and was done 100 to 200 times a day. Knee extension and flexion exercises of the patients while still in plaster were done for muscle strength building. The exercises were used using a combination of the same length resistance and isotonic contraction training. The loads were gradually increased, and the training for muscle fatigue was done daily.

Joint activity training was carried out by the lower limbs continuous passive motion trainer, and a joint mobilization massage was used when the plaster was removed. The quadriceps training chair was applied in the sitting joint flexion traction to increase the range of motion when the knee flexion was over 90°. For additional training, the patient was placed in a massage bed in the prone position where a passive flexing of their knees was done to increase joint flexion. Patients were encouraged to perform daily rehabilitation on their own. Motion range training was encouraged, and the patients were told to endure as long as they could. To restore the maximum flexion of the joint, consolidated therapies two to three times a week were continued in order to maintain the motion range. Patients were also told to continue their own training. Topical analgesics supplemented by ultrasound, semiconductor laser, and intermediate frequency electrical stimulation therapies were used in the training process to promote tissue repair, prevent adhesions, and relieve pain.

Joint balance function and endurance training was added 2 to 3 weeks after surgery. Balance function training was mainly done by the patients while standing on one leg with their eyes

Fig. 1 A 44-year-old male patient with postburn extension contracture for 18 months. **a** Stiffness of both knees preoperatively, with 20° of flexion of the left knee. **b** Forty degrees of flexion of the right knee. **c** Arrow showed fibrosis and shortening of vastus medialis in the operation. **d** Marked restoration of flexion degrees of the left knee at 6 weeks after operation. **e, f** Functional recovery of both knees in flexion and extension at follow-up of 28 months postoperatively

closed and their arms hugging their body to increase the difficulty. Joint endurance training was done by walking and riding a power bike.

Functional Evaluation and Statistical Analysis

At the end of the discharge and follow-up, knee painless activity was measured twice and compared with its preoperative range of motion. The preoperative joint function's HSS knee score was compared with the follow-up score. Statistical significant analysis was done using SPSS 13.0 paired *t* test for the pre- and postoperative motion ranges and the HSS knee function score change.

Results

General Information

In this group of patients, the intra-articular fibronectin was not noticeable, and a small amount of adhesions were detected in

the patella and both sides of the intercondylar expansion during surgery. Fibrosis shortening of the vastus intermedius muscle and skin scar tension was the main reasons for the burned knee's stiffness. The fibrosis and shortened vastus intermedius muscles were excised. Heterotopic bone resection was done to four patients who exhibited knee joint organization.

Treatment Effect

All of the patients' incisions healed well. Some patients came with a short-term weakness in extensor strength, although their extensor strength was above grade IV after 6 months of recovery. The patients' hospital's rehabilitation time was from 4 to 6 weeks. Their knee flexion at discharge increased significantly above 90° compared with their preoperative flexion, and their joint function recovery was able to satisfy their needs for daily activities (Fig. 1d). The follow-up for this group of patients was between 16 and 36 months, with an average of 25.7 months. At the end of the follow-up, the knee flexion was measured to be from 110° to 135°, with an average of $122.2^\circ \pm 11.0^\circ$ and an increase of 96° ($P < 0.01$) compared to the

Table 1 Hospital for Special Surgery Knee-Rating Scale

Criteria	Points
Pain (30 points)	
No pain at any time	30
No pain on walking	15
Mild pain on walking	10
Moderate pain on walking	5
Severe pain on walking	0
No pain at rest	15
Mild pain at rest	10
Moderate pain at rest	5
Severe pain at rest	0
Function (22 points)	
Walking and standing unlimited	12
Walking 5–10 blocks and intermittent standing (<1/2 h)	10
Walking 1–5 blocks and standing up to 1/2 h	8
Walking less than 1 block	4
Cannot walk	0
Climbing stairs	5
Climbing stairs with support	2
Transfer activity	5
Transfer activity with support	2
Range of motion (18 points)	
1 point for each 8° (max=18 points)	18
Muscle strength (10 points)	
Excellent: cannot break quadriceps power	10
Good: can break the quadriceps power	8
Fair: moves through the arc of motion	4
Poor: cannot move through arc of motion	0
Flexion deformity (10 points)	
No deformity	2
Less than 5°	2
5–10°	2
>10°	2
Instability (10 points)	
None	10
Mild (0–5°)	8
Moderate (5–15°)	5
Severe (>15°)	0
Subtraction	
One cane	–1
One crutch	–2
Two crutches	–3
Extension lag of 5°	–2
Extension lag of 10°	–3
Extension lag of 15°	–5
Each 5° of varus	–1
Each 5° of valgus	–1

patient's preoperative knee flexion. Furthermore, the joint function improved compared with when the patients were discharged (Fig. 1e, f). The HSS knee function scores at the end of follow-up ranged from 93 to 100 points, with an average of 97.5 ± 1.9 and an increase of 41.7 points ($P < 0.01$) compared with the patient's preoperative HSS knee function scores.

Discussion

The main pathological changes of the burned joint stiffness are scar formation and articular soft tissue contracture caused by the patient's long-term immobility [9, 10]. Some of the patients had their ectopic bone formatted [11, 12]. In addition, the patella and its two sides and the expansion of the quadriceps tendon as well as the intercondylar parts are often lighter in intra-articular adhesions, which are different from the pathological changes from orthopedic trauma knee stiffness [13, 14]. The vastus intermedius muscle is the most noticeable muscle in soft tissue contracture, and the rupture of the muscle is very prone to fibrosis, resulting in the loss of muscle flexibility. Fibrous contracture must also be cut in the knee release; otherwise, there will be no improvement in a range of movements. Patients suffering from a longer period of stiffness often have mild rectus femoris contracture. However, this contracture can get better by intra-operative lysis after short-term fixation and active postoperative rehabilitation. In conclusion, quadriceps tendon-lengthening surgery should not be easily implemented to avoid increasing the surgical trauma and postoperative healing time, which affects the straightening of the joint's extension and the recovery of the extensor muscle's strength. The ectopic bone should be removed after it has matured. The usual duration is 8 to 12 weeks. At the same time, measures should be taken to prevent recurrence. In addition, pre- and postoperative medication and radiation are helpful in reducing the recurrence of the heterotopic bone [15].

Skin scar contracture tension and joint stiffness are important factors in a patient's recovery from burns [16–18]. Skin grafting is commonly used to handle skin tightening in knee straight stiff release surgery to treat burns. Retrograde fascia flap release surgery can repair skin and soft tissue defects [4]. Yildirim et al. reported that the front of the thigh flap can be used in covering skin and soft tissue burned joint stiffness after surgery [5]. Prakash used the posterior leg fascia flap to resolve the knee skin scarring tension [6, 7]. The Z plasty is also recommended by surgeons [19]. During the release surgery procedure, surgical traumas are very serious because they need to be implemented with a full soft tissue lysis and a wide range of skin grafting. In fact, the effect of some patients was not very ideal after the treatment, because pressure bandage

and immobilization after skin graft may lead to loss of post-operative range of motion and even stiffness again [5, 20].

As previously reported, there are applications for the external fixator without resorting to skin grafting to treat burned stiff joints. Barquet et al. specially designed an external fixator to gradually and slowly draw the flexion contracture of patients with knee stiffness, which resulted in satisfying effects [21]. Saghieh et al. applied Ilizarov external fixation to solve skin ductility difficulty in three cases of burned ankle stiffness patients [22]. There were also reported external fixation and free flap combined applications for severely recurrent flexion joint stiffness [23]. The flap traction (flap stretching) is also commonly used for burned skin scar contractures [24]. There are some cases where this procedure was used for knee, elbow flexion contracture, or ankle stiffness treatments.

The remaining elasticity of burned skin can be utilized in knee straight stiffness therapy in order to draft and increase skin ductility. The full release of soft tissue, freeing of shade fascia in surgery, and the active rehabilitation after operation are beneficial for the gradual drawing of skin tissue and the significant increase of skin ductility. The patient's skin can be restored to meet the knee joint range of skin coverage requirements, providing a new choice for the treatment of stiff joints after burns and avoiding skin grafting trauma. However, if the burned skin surrounding the joints are deeper, scarring occurs more. Therefore, the surface is repaired by skin graft, which may create an apparent lack of flexibility of the skin and make it is not suitable be dealt with using the method in this article.

Placing the operated knee in a maximum flexion angle is a good way to increase postoperative skin ductility and can help prevent the skin and soft tissue adhesion as well as drawing tension. However, skin scarring and contracture problems occur due to the stiff joints caused by the burns. Therefore, buckle placement after the release should be done carefully to prevent the complications of prepatellar skin necrosis. The maximum fixation in flexion should be conducted to avoid the prepatellar skin being pale, which means that the flexion degree is too large to prevent the squeezing ischemia of local skin. Three to 4 days is the right length of time for postoperative immobilization, and it is also the adequate duration for the use of patient-controlled analgesia (PCA) pump.

Postoperative and effective rehabilitation is another important way to increase skin ductility. It is an important step to achieve better efficacy without skin grafting for treating knee stiffness after burns. Rehabilitation after the release of active and passive drawing has a very key role in the restoration of joint function and skin ductility. Without close coordination and positive rehabilitation, it is difficult to consolidate the knee release surgery effect, which can lead to a reduction of motion range and a recurrence of stiff joints. It is necessary to attach importance to the training of joint activity, muscle

strength, balance, and endurance in order to promote the full restoration of joint function in the postoperative rehabilitation process.

Conflict of Interest All authors have no conflict of interest regarding this paper.

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