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Evaluation of the Therapeutic Efficacy of the Bone Transport Technique in the Treatment of Patients with Infected Tibial Nonunion

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Abstract: *Objective:* To evaluate the therapeutic effect of bone transport technique in patients with infected tibial nonunion. *Methods:* 30 patients with infected tibial nonunion admitted to our hospital from January 2021 to January 2023 were selected as the subjects of this study, and were divided into two groups according to the different treatment methods. 15 patients in the control group were subjected to conventional surgical treatments, and another 15 patients in the observation group were treated with bone transport techniques. The operation time, intraoperative bleeding, hospitalization time, incidence of postoperative complications, and the total effective rate of treatment were compared between the two groups. *Results:* The operation time and the hospitalization time of the observation group were shorter than that of the control group, and the intraoperative bleeding of the observation group was less than that of the control group ($P < 0.05$); the observation group had a lower incidence of postoperative complications than the control group ($P < 0.05$); the observation group had a higher total effective rate of treatment than the control group ($P < 0.05$). *Conclusion:* In the treatment of infected tibial nonunion, the application of bone transport technique can achieve better therapeutic effects, shorten the operation time, reduce intraoperative bleeding, lower postoperative complications, and promote the early recovery of patients.

Keywords: Infected bone defect of tibia; Tibial nonunion; Bone transport technique; Treatment effect

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1. Introduction

Severe traumatic injuries to the lower leg caused by falling from height, traffic accidents, or heavy objects need to be treated promptly, or else serious complications such as infected bone defects and bone nonunion may occur. Infected bone nonunion is caused by persistent bacterial infections at the location of the fracture and the subsequent failure of the fracture to heal properly [1]. It usually occurs after severe trauma is not treated properly and prolongs the overall course of the disease, requiring multiple surgeries and causing great pain to the patient. Currently, the clinical recommendation for infected bone defects and nonunions in the tibia is to implement the bone transport technique, which involves adjusting an external fixator according to the predicted rate of bone growth so that the bone fragments are slowly docked with each other to achieve the therapeutic goal [2]. In this study, we analyze the therapeutic effect of the bone transport technique in patients with infected tibial nonunion.

2. General information and methods

2.1. General information

A total of 30 cases of patients suffering from infected bone defects and bone nonunion in the tibia admitted to our hospital from January 2021 to January 2023 were selected as the subjects of this study, and were divided into 15 cases in the control group and 15 cases in the observation group according to the different treatment methods.

In the control group, there were 10 males and 5 females, age ranged from 28 to 81 (43.63 ± 5.26) years old; the duration of disease ranged from 1 to 7 (2.30 ± 0.30) years; in terms of the cause of injury, there were 10 cases of traffic accidents, 3 cases of fall from height, 1 case of heavy object injury, and 1 case of machine strangulation; according to the Gustilo classification, there were 1 case of type I, 3 cases of type II, 3 cases of type IIIA, 6 cases of type IIIB, and 2 cases of type IIIC. The observation group had 9 males and 6 females, age ranged from 26 to 80 (43.50 ± 5.14) years old; the duration of disease ranged from 1 to 6 (2.41 ± 0.25) years; for the cause of injury, there were 11 cases of traffic accidents, 2 cases of fall from height, 1 case of heavy object injury, and 1 case of machine strangulation; according to the Gustilo classification, there were 1 case of type I, 3 cases of type II, 2 cases of type IIIA, 6 cases of type IIIB, and 3 cases of type IIIC. The data of the two groups were statistically analyzed, and it was concluded that $P > 0.05$.

Inclusion criteria included patients meeting the diagnostic criteria of the disease; patients without other serious diseases, such as organ failure, malignant tumors, etc.; patients meeting the indications for treatment; patients having basic communication, understanding, and cognitive expression ability; patients with complete clinical data and informed consent.

Exclusion criteria were the presence of comorbid mental illness or serious psychological illness; patients with previous major surgery; patients with a history of taking special drugs; and patients who dropped out in the middle of the study.

2.2. Methods

After the admission of the two groups of patients, all of them received routine examinations, such as X-ray examination, cardiopulmonary function examination, etc. They underwent preoperative preparations, such as clarifying the defective condition of the fracture end and the traumatic infection, and patients with acute infection received targeted anti-infection treatment.

The control group received conventional surgical treatment. The lesion was first removed, a thorough debridement treatment was given, and the infection was controlled. An autologous free bone grafting was performed, if there was a large segmental bone defect, it was filled with vascularized bone flap transplantation.

The observation group adopted treatment using the bone transport technique. For patients with internal fixation, the internal fixation was taken out before treatment. If there was a severe infection, debridement was first carried out to remove all necrotic tissues as well as bone, and they were sent for bacterial culture and drug sensitivity test to select antibiotic treatment. After which, the severed end of the bone defect was cut off, and the wound was rinsed with saline and hydrogen peroxide repeatedly and then bandaged. The Orthofix external fixator was installed in the proximal tibial osteotomy position. After fixation, most of the skin defects were sutured. If there was a severe infection in the wound that could not be closed, an open dressing was performed, along with a direct suture of the drainage tube.

2.3. Observation indexes

(1) The operation time, intraoperative bleeding, and hospitalization time of the two groups were compared.
(2) The postoperative complications of the two groups were compared.
(3) The treatment effects of the two groups were compared [3]. The final results were evaluated by referring to the Johner-Wruhs criteria. If the fracture healing time did not exceed five months, and the knee and ankle joints can move normally, with normal gait and no pain, and can walking freely, it was evaluated as "excellent." If the fracture healing time did not exceed 8 months, and the functions of knee and ankle joints partially recovered, with a slight limp and limited self-care, it was evaluated as "good." The fracture healing time of not more than one year, and the knee and ankle joint functions improved compared with that before the operation was assessed as "moderate." If the fracture had not healed, with relatively poor ankle joint function, and the limb was shortened by more than 1 cm and the angular deformity was more than 10 degrees, it was considered "poor." Total effective rate of treatment = [(number of excellent cases + number of good cases + number of moderate cases)/ total number of cases in the group] × 100

2.4. Statistical methods

The data were entered into the SPSS25.0 statistical software for analysis. Mean ± standard deviation (SD) was used to indicate the measurement data (conforming to normal distribution), and [n (%)] was used to indicate the count data, and independent sample *t*-tests and χ^2 test were carried out respectively. $P < 0.05$ indicated that the compared data were statistically significant.

3. Results

3.1. Surgery-related indexes

As shown in **Table 1**, the observation group had shorter operation time and hospitalization time, and less intraoperative bleeding than the control group, $P < 0.05$.

Table 1. Surgery-related indicators (mean ± SD)

Group	Number of cases (n)	Operation time (minutes)	Intraoperative bleeding (ml)	Duration of hospitalization (days)
Control group	15	93.52 ± 5.34	218.52 ± 10.17	16.31 ± 3.12
Observation group	15	67.17 ± 6.13	102.45 ± 9.31	11.81 ± 2.26
t	-	12.553	32.604	4.524
P	-	0.000	0.000	0.000

3.2. Postoperative complications

As presented in **Table 2**, the incidence of postoperative complications in the observation group was lower than that in the control group, $P < 0.05$.

Table 2. Postoperative complications [n (%)]

Group	Number of cases (n)	Neurological symptoms	Pain	Pin tract infection	Total
Control group	15	2 (13.33)	2 (13.33)	2 (13.33)	6 (40.00)
Observation group	15	1 (6.67)	0 (0.00)	0 (0.00)	1 (6.67)
χ^2	-	-	-	-	4.658
P	-	-	-	-	0.031

3.3. Treatment effects

Based on **Table 3**, the observation group had a higher total effective rate of treatment than the control group, $P < 0.05$.

Table 3. Treatment effects [n (%)]

Group	Number of cases (n)	Excellent	Good	Moderate	Poor	Total effective rate
Control group	15	3 (20.00)	4 (26.67)	2 (13.33)	6 (40.00)	9 (60.00)
Observation group	15	8 (53.33)	5 (33.33)	1 (6.67)	1 (6.67)	14 (93.33)
χ^2	-	-	-	-	-	4.658
P	-	-	-	-	-	0.031

4. Discussion

With the development of the transportation industry and the construction industry in recent years, there are increased incidences of traffic accidents, falling from height, and other accidents. These accidents can lead to multiple injuries throughout the body, of which fractures are more common. Among the injuries, tibial trauma and post-traumatic infections need to be dealt with in a timely manner, otherwise soft tissue defects and necrosis may occur. In severe cases, the trauma may occur in the exposed bone [4], bone and soft tissue infections can slowly evolve into skin defects, as well as chronic osteomyelitis, sinus tract formation, and later infected bone nonunion [5], increasing the treatment difficulty.

Bone transport technique is a novel treatment technique, which uses external fixator and tensile force in the Ilizarov system to treat bone defects. In bone transport, the length of the limb is maintained by the external fixator, and the bone is amputated in the epiphysis of the long bone that has rich blood supply. Simultaneously, the broken end of the bone defect is repaired [6], and the amputated bone segments are moved at a certain speed, so that the normal living bone is slowly delivered to the defect site. The treatment principle lies in that, firstly, after the lesion is removed during the operation, the affected limb is kept in a stable framework [7]. Secondly, the bone end is pulled every day to facilitate tissue repair and regeneration, and to promote the formation and regeneration of soft tissues, such as muscle, skin, as well as bone tissues. Lastly, a sustained elastic pressure is formed between the osteotomy extension area and the bone end as well as the confluent end of the bone block [8], which is conducive to the accelerated regeneration of osteogenic area. The bone at the confluence of defects is regenerated through a form of guided bone regeneration, and the bone in the lengthening zone is regenerated through the formation of distraction bone regeneration [9].

Conventional surgical treatment involves repeated removal of the lesion, thorough debridement, control of infection, and vascularized bone flap transplantation or autologous free bone grafting to fill up the bone defect. In this therapy for large bone defects, a high level of microsurgical skill is required, and the soft tissue and blood supply should be ideal and adequate. In addition, conventional surgical treatment is prone to reinfection and requires a relatively long treatment period. The repeated surgeries will worsen the soft tissue condition [10], increasing the treatment difficulty, and may even lead to amputation. The bone transport technique can shorten the treatment time with ideal outcomes. Especially when dealing with cases of severe infected bone nonunion combined with soft tissue defects, the limb can be preserved and limb function can be actively restored [11,12]. Additionally, complications such as pain and pin tract infection can be prevented through timely follow-up and early intervention. The Orthofix unilateral lengthener is simple to operate and does not affect functional exercise in the later stage, but the stability is not as good as the ring external fixation (Ilizarov frame) [13]. At the same time, it is susceptible to offset during movement, so it is necessary to carry out the moving operation under the monitoring of the X-ray imaging, and timely adjust the offset position [14,15]. When dealing with infected wounds at the end of the bone, it is necessary to thoroughly remove the necrotized bone and inflammatory tissues, as well as the original internal fixation, and it will possibly lead to the recurrence of bone infection if there is any residual lesion [16]. The data from the results of this paper showed that the observation group had a shorter operation time, less intraoperative bleeding, and a reduced hospitalization time than the control group; moreover, the incidence of postoperative complications in the observation group was lower than that in the control group; and the total effective rate of treatment in the observation group was higher than that in the control group, so it is evident that the overall therapeutic effect of the bone transport technique is more satisfactory.

5. Conclusion

In conclusion, infected tibial nonunions are difficult to treat. This study found that the effect of adopting the bone transport technique for the treatment of infected tibial nonunion is more satisfactory and it is worth adopting.

Disclosure statement

The authors declare no conflict of interest.

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