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Backstroke technique: an effective way to improve the healing of tibia fracture

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Abstract To assess the method and results of applying a backstroke technique, we treated 43 patients with tibial shaft fracture using unreamed tibial nails (UTN). Of these patients, 27 suffered a closed fracture and 16 an open fracture. After the operation, the effect of treatment was evaluated: 42 of 43 cases were followed up from four to 18 months, averaging 13.6 months. The four-month and 12-month healing rates of open fracture were 54.6 and 80.9%, respectively, the former of which is significantly higher than the average rate of the AO/ASIF multicentre study. Our results indicate that applying a backstroke technique in treating tibial shaft fracture with UTN can improve the healing rate and reduce complications.

Résumé Résumé: Afin d'apprécier la méthode et le résultat du traitement des fractures de la diaphyse tibiale avec un clou d'alignement, nous avons opéré 43 patients présentant une fracture de ce type. Parmi tous ces patients, 27 présentaient une fracture fermée, 16 une fracture ouverte. Après opération, les résultats du traitement ont été évalués. 42 patients sur 43 ont été suivis de 4 à 18 mois avec une moyenne de 13,6 mois. Le taux de consolidation des fractures à 4 mois et un an était respectivement de 54,6% et 80,9%. Ce taux est nettement supérieur à celui de l'étude multicentrique de l'AO/ASIF. Notre étude prouve que cette technique dans le traitement des fractures tibiales à l'aide d'un clou d'alignement UTN peut améliorer la consolidation et diminuer le nombre de complications.

because of the low rate of infection. Besides, it also destroys less of the blood supply to the endoperiosteum [8, 14], compared with the reamed tibial nail (RTN). Therefore, it is of special advantage for us to use UTN in treating open fracture [2]. During the operation using UTN, the AO/ASIF organization strongly recommends the backstroke technique immediately after distal interlocking. However, details on usage and the therapeutic effect of the technique have hardly been referred to in the literature. From August 2003 to June 2004, we applied UTN to treat tibial shaft fracture. Meanwhile we have studied the effect of the backstroke technique on treatment.

Materials and methods

There were 43 cases of tibial shaft fracture altogether, of which 28 suffered fracture of both the tibia and fibula. There were 30 men and 13 women. The age of the patients ranged from 21 to 53 years (average: 36.2); 27 had a closed fracture and the remaining 18 an open fracture. We chose cases of fresh fracture to include in the study. According to the AO Müller classification, 22 cases of fracture were defined as type A, 15 were type B, and 6 were type C. All open fractures were classified as Gustilo-Anderson standard: nine cases were type I, five were type II, one was type IIIA, and one was type IIIB. The causes of injury were traffic accident in 30 cases, falling in eight, and smashing in five.

Introduction

The unreamed tibial nail (UTN) has been increasingly applied in recent years to treat fracture of the tibial shaft

Operation technique

The entry point must be very proximal, no more than 1 cm distal to the anterior edge of the tibial plateau. An awl is used to open the medullary canal in midline, keeping the straight part of the shaft of the awl parallel to the long axis of the tibial shaft. An image intensifier check in both the sagittal and frontal planes should confirm that the tip of the awl or guide pin is in the line of the tibial canal. A guide wire is inserted through the entry portal and passed through the proximal fragment. The guide wire is manipulated in such a way that it reaches the distal fragment. Guide wire

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Fig. 1 A 38-year-old man who sustained a right lower middle-third tibial and fibular fracture was treated with UTN 5 days after injury. We conducted a backstroke technique after distal locking and used static interlocking (proximal vertical interlocking) in this case for stability

insertion must be carried out under image intensifier control in two planes. Insert the nail manually and it must be remembered that the nail will follow the guide wire. Reduction will be completed once the nail enters the distal fragment. Perform distal locking (parallel or vertical interlocking) with the help of the jig after the insertion of the nail. Backstroke the nail discreetly with the taper under intensifier control until the fragments unite closely or the tibia reaches reserved length. Decide whether to apply proximal locking according to the type of fracture (condition of stability). In this study, all were static interlocking, except for two cases of A3 fracture (dynamic interlocking).

Post-operative treatment

All cases received IV injection of antibiotics one to three days after operation. Administration of the medication was changed to an oral route from the 4th day until the body temperature became normal. The wound was dressed once one day after the operation, and once every three days thereafter. We took out the stitches 14 days post-operation. We required the patient to make passive bending motions of the knee and ankle joint (with the help of CPM). All cases were examined once a month during the six month postoperative period and once two months afterwards. Examinations included X-ray and measurement of range of motion of the knee and ankle joint. Partial weight bearing was permitted after callus formation displayed by X-ray and complete weight bearing after clinical healing of the fracture.

Statistical analysis

We applied the chi-square test of a fourfold table with statistical software (SAS 8.10) to compare clinical data and statistical significance was defined as $P < 0.05$.

Results

Except for nine cases of Gustilo type I that were managed as surgical emergencies, all open fractures were débrided and the wounds were repaired with dermatoplasty and skin flap transfer before external fixation or calcaneal bone traction. Operations were performed four to 14 days later. The average operation time was 55 min (40–150 min) and the average bleeding volume was 85 ml (0–700 ml). Blood transfusion was not required in 39 cases. Closed reduction was done in 20 cases and open reduction in 23 during the operation (Figs. 1, 2). A total of 42 cases were followed up (Fig. 3a,b) for 6–18 months (13.6 months on average). Except for delayed union in one case of IIIB fracture (bad soft tissue damage) and two cases of closed fracture (senile patient with osteoporosis), no complications occurred in this study. The conditions of fracture healing are shown in Table 1.

Discussion

Only by strictly following indications can treating tibial fracture with UTN achieve a good outcome. According to the study of Schmidt et al. [15], compared with a steel plate and external fixator the intramedullary nail is more suitable

Fig. 2 A 45-year-old women suffered from IIIA multisegmental open fracture (according to the Gustilo-Anderson classification) in the left tibia and fibula. Débridement and calcaneal bone traction were done until the soft tissue was well covered; 14 days later, surgery was performed. We also applied a backstroke technique in this case

Fig. 3 A 29-year-old man suffered from Gustilo-Anderson type II fracture. Thorough débridement was followed by primary wound closure. Operation with backstroke was done 10 days after the injury. The patient was followed up for a year. Callus formation and clinical healing were achieved 6 months (a) and a year (b) after the operation, respectively

for most unstable tibial closed fractures. In terms of biomechanics, the intramedullary nail is mainly used to control flexion and lateral displacement. Stress will reach the distal fragment from the proximal part via the nail and distal locking screws, respectively, which can keep the fracture from stress of angulation, compression, and bending. Intramedullary nails may be divided into reamed and unreamed nails. A thicker nail can be used after the canal has been enlarged. Reaming will also increase the area of contact between the nail and inner wall, which can

raise its mechanical stability. Furthermore, reaming has the effect of a local bone graft. Finkemeier et al. [6] performed a randomised prospective study on 94 cases of open and closed tibial fractures (Gustilo type IIIB and IIIC exclusion fractures) to compare the effect of reaming and not reaming. The results showed that the healing rate of the reamed group was significantly higher than that of the unreamed ($P=0.04$), while there was no significant difference in postoperative complications between the two groups ($P=0.155$). Larsen et al. in a prospective study over 3.8 years [10] discovered that both the re-operation rate and the non-union rate of the unreamed group were higher than in the reamed group ($P=0.004$). Those who objected to this approach believed that reaming would destroy the blood supply to the endosteum and cause high intramedullary pressure. The latter might lead to osteonecrosis and fat embolism. A multicentre clinical experiment [12] of the AO organization suggested that it is significantly important to protect the blood supply to fragments when treating tibial shaft fractures. It will not only improve fracture healing but prevent infection as well. However, the unreamed nail achieves its biological advantage at the expense of mechanical stability [5]. The main disadvantage of it has been the relatively high incidence of non-union and breakage of metal [1]. It is not suitable for fixation of distal tibial fractures.

The reamed nail is not suitable for open fracture, for reaming will further destroy the blood supply to the endosteum, which may cause sequestration and raise the non-union and infection rates. However, the unreamed nail can reduce contact in the marrow cavity. It is effective in treating types I and II open fractures. Joshi et al. [7] treated 60 cases of open tibial fracture with UTN, among which 30 cases were Gustilo type I fracture, 18 were Gustilo type II, four were Gustilo type IIIA, and four were Gustilo type IIIB. The results were good to excellent in 85.5% according to the modified Ketenjian standard and six cases of type III suffered from chronic osteomyelitis. Both open and closed fractures were selected in our research. All types of fracture including one case of grade IIIA and one of grade IIIB were included in the study. For the operation, we applied the backstroke technique recommended by the AO after distal locking to oppose the fragments, which generated a compression effect. The technique avoids separation of fragments during insertion, which aids fracture healing. Therefore, in the open fracture group, the average four month healing rate of our study is higher than the multicentre study of Markmiller et al. [12]. In our experience, it is not an absolute taboo to apply UTN in

Table 1 Effect of backstroke technique on fracture healing (compared with AO multicentre clinical research [12])

	Open group ($n=16$)		χ^2	Closed group ($n=27$)		χ^2
	Our research	AO		Our research	AO	
Healing rate at 4 months	54%	40%	3.93*	57%	61%	0.3307
Healing rate at 6 months				72%	75%	0.2310
Healing rate at 12 months	71%	80%	2.19	89%	92%	0.5234

* $P<0.05$

type III open fracture. A good result can be achieved provided that the wound is treated suitably before operation [3]. In the study, we applied the technique of débridement, dermatoplasty, and flap transfer. The operation was conducted 14 days later. All cases healed well and no failure of internal fixation occurred.

The common complications of intramedullary nails include infection, compartment syndrome, delayed union or non-union, breakage of nail and screws, malunion, etc. Though the incidence of compartment syndrome is comparatively low, the outcome is quite serious, and affects the fracture healing. The incidence of the syndrome in closed lower leg fractures and type I open fractures is about 1%. Reaming and nail insertion will further increase the pressure in the compartment. Nassif et al. [13] compared the effect of reaming and not reaming on compartment pressure. The study suggested that increase in compartment pressure in the reamed group was significantly lower than in the unreamed group ($P < 0.05$) 10, 12, 14, 16, 18, 20, 22, and 24 hours after operation. No case of compartment syndrome occurred in our study. It is plausible that backstroking correspondingly reduces the pressure in the compartment. Lower pressure also improved conditions for early fracture healing. As to the angulation of distal screws, Chen et al. [4] believed that the stability could not be significantly influenced by the angle (parallel or vertical interlocking). Internal and external rotation deformity [11] of the knee and chronic anterior knee pain [16] are also common postoperative complications, which can be avoided by choosing a suitable entry point. Concerning the fibula, a relevant biomechanical test [9] displayed that bias under axial loading of 53–71 N between the steel plate group and control group was significantly different ($P < 0.05$), but the rotational stiffness between the two groups was of no significant difference. We fixed the fibula with a 1/3 tubiform steel plate in most cases while conducting open reduction of the tibia to enhance the stability of the fracture.

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