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Review Article

FRACTURE UNION WITH CLOSED INTERLOCKING NAIL IN SEGMENTAL TIBIAL SHAFT FRACTURE

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ABSTRACT

A segmental fracture of the tibial shaft is a major cause of morbidity and mortality in patients with lower extremity injuries. From December 2010 to December 2014, Thirty-four patients (28 males and 6 females) with segmental tibial fractures were recruited from Emergency and outpatient department and compared healing and complications with a matched control group of Thirty-four non-segmental tibial fractures. In follow-up, we determined the time to union, delayed and nonunion and overall complication rates. All patients were followed for twelve months. Majority of the patients had a union in 120 to 180 d with a mean of 160.58. The results were excellent in 79.41 % (27/34) and good in 14.70 % (5/34) patients in segmental fractures and excellent in 91.17 % (31/34) and good in 5.88 % (2/34) patients in non-segmental fractures. 5.88 % (2/34) of our patients was labeled as non-union and14.75 % (5/34) delayed unions in segmental fractures, and 2.94 % (1/34) non-union, and 5.88 % (2/34) delayed union in non-segmental fractures and was treated by bone graft and dynamization. Insignificant limb shortening of less than 1.5 cm was found in both the groups. Majority of the segmental tibial fractures had severe soft tissue injuries and demanded prolonged treatment and with an uncertain clinical and functional outcome.

Keywords: Segmental tibia fracture, intramedullary interlocking nail, Reaming, Nonunion

INTRODUCTION

Segmental tibia fractures are usually caused by a high-energy trauma and have a significant complication rate. They are uncommon injuries, and that occur in about 12.8 % of tibial fractures [1]. They are caused by high-energy injuries; motor vehicle and motorcycle crashes, falls from a height, industrial and train accidents. It is estimated that almost 37.5 % to 83.8 % of these fractures are open [2, 3]. They are often a part of multiple injuries. Segmental tibia fractures are generally associated with severe soft tissue injury and periosteal stripping, resulting loss of blood supply to the central fragment. Interlocking nailing of these fractures provides improved clinical and functional outcome [4, 5]. Unreamed intramedullary interlocking nailing preserves the endosteal blood supply and provides minimal harm to the soft tissue envelope. Nonunion and delayed unions are commonly seen with segmental tibia fractures as compared with non segmental fractures [6-8]. The aim of this study was to evaluate the outcome of interlocking nailing in segmental tibial shaft fractures.

Patients and methods

This prospective study was carried out at Orthopaedics department of School of Medical Sciences and Research, Sharda University from December 2010 to December 2014. It was approved by institutional medical ethics committee. A total of 34 patients with segmental fracture of the tibia and compared healing and complications with a matched control group of Thirty-four non-segmental tibia fractures admitted to our institute were included in present study. A written informed consent was obtained from all the patients; they were explained about the treatment plan, the cost of operation, and hospital stay after surgery, and complications of anaesthesia. They were followed up after surgery, were clinically and radiologically assessed for fracture healing, joint movements and complications. According to the criteria the results are graded as excellent when the fractures unite within 16 w without any complication, good when union occur within 24 w with treatable complications like superficial infection and knee stiffness and poor when union occur before or after 24 w with one or more permanent complications like infection (osteomyelitis), implant failure, non-union, limb shortening and permanent knee and ankle stiffness. Segmental fractures were defined as fractures featuring, at least, two distinct fracture lines that created a completely separate cylindrical intermediate segment. During the study time, we treated a total of 68 patients with fractures of the tibial diaphysis. Out of 68 tibial shaft fractures, 34 fractures were segmental (study group), and 34 were non-segmental (control group). All fractures were classified according to the Association for the Study of Internal Fixation (AO) classification system[7], and the Gustilo and Anderson classification in case the fracture was open [8,9]. According to the AO classification system, segmental tibial fractures were classified as AO type 42C2 and non-segmental tibial shaft fractures classified as AO type 42A or 42B. The median age of the patients was 47 y (range, 16-86 y). The control group of 34 cases did not differ from the study group in characteristics such as age, sex, additional injuries, the amount and type of open fractures, and presence of diabetes which potentially affects fracture healing negatively. The time of initial surgery, duration of initial surgery, type of initial fixation and length of initial hospital stay did not differ between the two groups. Follow-up was done for twelve months. Patients with segmental tibia fracture with age more than 16 y and presented within a week of the injury and did not have any previous surgical treatment for the fracture was included in the study. We excluded malnourished patients, pathological fractures and fracture nonunion from the study. Patients were thoroughly examined at the time of admission to exclude other injuries. In the majority of the patients close reamed interlocking nailing of the tibia was performed within seventh to the fourteenth day after the injury in closed fractures and within 24 h in open fractures. Those patients who were not fit for surgery due to some associated injuries to vital organs, were haemodynamically unstable or due to active infection at injury site or were pyrecxial delayed, interlocking nailing was performed when their overall condition improved The criteria used for acceptable fracture reduction and alignment: -more than 50 % of cortical contact; -less than 5-10 deg of varus/valgus angulations when comparing tibial plateau to tibial plafond (some will not accept more than 5 deg of varus); less than 10-15 deg of anterior or posterior bowing on lateral film; varus or valgus; -no more than 10-15 mm of shortening; -less than 2-3 degree of internal or external rotation. There were 22 static nails used and 12 dynamic nails used. Patient's mobilization depended on the type of fixation and fracture fixation on the postoperative radiograph. Postoperative rehabilitation consisted of supportive mobilization with crutches, initially with partial weight bearing. Full weight bearing was allowed when there was evidence

of a bridging callus on both the AP and lateral projections at most often 6 w postoperatively (fig. 1a, 1b, 2a and 2b). Patients were followed at the outpatient clinic at intervals ranging from 4 to 6 w in the first 6 mo after hospital discharge and 4 to 12 w thereafter. Clinical evaluation comprised assessment of pain or tenderness at the fracture location, pain during walking and weight bearing, and stability and potential deformity at the fracture location. Union was said to have occurred when a mature bridging callus of the four cortices on both AP and lateral radiographic views and painless full weight bearing. Time to union was counted from the initial trauma irrespective of intermittent surgery. Delayed union was defined as not achieving union within 6 mo from the initial trauma, whereas nonunion was defined as persistence of fracture at 9 mo from the initial trauma without any tendency to the progressive union in the previous 3 mo [10]. Statistical analysis was limited to calculation of the percentage of patients who had unions, malunions, delayed unions, or non-unions and Excellent, Good, and poor outcomes. Functional outcomes were evaluated according to the Johner and Wruhs (1983) criteria [28].

RESULTS

There were thirty-four patients in this study, 82.35 % (28/34) patients were male, and 17.64 % (6/34) patients were females. The patients were aged sixteen years to eighty-six years. There were 55.88 % (19/34) left sided and 44.11 % (15/34) right-sided fractures. 79.41 % (27/34) patients had met with a road traffic accident, and 20.58 % (7/34) had a fall from a height. Out of 100 % (34/34), 44.11 % (15/34) were open fractures (Gustilo and Anderson type 1 and type 2) and 55.88 % (19/34) were closed fractures. Out of 100 % (34/34), 82.35 % (28/34) patients had isolated segmental tibia fractures and 17.64 % (6/34) patients had polytrauma and multiple fractures. All patients were followed for twelve months. None was lost to follow-up. The clinical results of our study were based on the criteria of the union, nonunion [10], delayed union or malunion. The patients were followed according to their clinical status. 79.41 % (27/34) patients had a union in 120 to 180 d with a mean of 160.58. Two of our patients had diabetes. Union has achieved in 14.70 % (5/34) patients in 150-175 d with a mean of 133.38 (table 3). There were thirty-four patients in the control group, 76.47 % (26/34) patients were male, and 23.52 % (8/34) patients were females. 79.41 % (27/34) patients had met with a road traffic accident, and 20.58 % (7/34) had a fall from a height. Out of 100 % (34/34) patients, 35.29 % (12/34) were open fractures (Gustilo and Anderson type 1 and type 2) in the control group. The patients were divided into three groups. (table 1) Young age group included those patients whose age was less than forty years. In this group, there were 32.35 % (11/34) patients. Middle age group included patients, who were between the ages of 40-60 y. This group included 41.17 % (14/34) patients. Old age group included patients older than sixty years. This group consisted of 26.47 % (9/34). All patients were followed for twelve months. None was lost to follow-up. The clinical results of our study were based on the criteria of the union, nonunion [10], delayed union or malunion. (Table2, 3) The patients were followed according to their clinical status. 91.17 % (31/34) patients had union in 90 to 150 d with a mean of 110.68. Union has achieved in 5.88 % (2/34) patients in 95-109 d with a mean of 103.38. Median time to union was longer (p\0.001) for segmental tibia fractures compared with non-segmental tibia fractures: 160.58 d (range, 120–180 d) versus 110.68 d (range, 90-150 d), respectively. Rehabilitation-We allowed our patients to start touchdown walking with crutches on the 2nd day of operation as they feel comfortable. 94.11 % (32/34) patients started partial weight bearing on the 6th week and full weight bearing on the 12th week. 5.88 % (2/34) patients had non-weight bearing ambulation till callus became visible on radiographs. All of our patients had full range of motion of their knees and ankles. Out of 100 % (34/34), 8.82 % (3/34) patients complained post-operative knee pain, which was spontaneously resolved in two weeks. Our 20.58 % (7/34) patients needed dynamization within six weeks because of an obvious gap at the fracture site in subsequent radiographs. This was due to over distraction of fracture during operation. 20.58 % (7/34) patients were dynamized before starting partial weight bearing. There were 14.75 % (5/34) delayed unions in segmental fractures and 5.88 % (2/34) delayed union in non-segmental fractures which were treated by dynamization. In our study only 5.88 % (2/34) of our patients was labeled as nonunion in segmental fractures and 2.94 % (1/34) nonunion in non-segmental fractures and was treated by bone graft and dynamization. In our study, we did not found deep infection in a segmental and non segmental group of tibia fractures. Superficial infection was seen in 14.70 % (5/34) cases of segmental and 5.88 % (2/34) cases of non segmental tibia fractures which were subsided with three weeks of antibiotic treatment. Limb shortening of less than 1.5 cm was found in 8.82 % (3/34) cases in segmental fractures and 1 cm shortening in 2.95 % (1/34) in non-segmental fracture both clinically as well as radiologically, which was clinically insignificant. The results of both the groups were depicted in tables (table 4 and 5) The results were excellent in 79.41 % (27/34) and good in 14.70 % (5/34) patients in segmental fractures and excellent in 91.17 % (31/34) and good in 5.88 % (2/34) patients in non-segmental fractures. (table 4, 5) In the overall subjective assessment, 79.41 % (27/34) patients were full satisfied in segmental fractures, and 91.17 % (31/34) patients were full satisfied in non-segmental fractures and14.70 % (5/34) were satisfied with segmental fractures and 5.88 % (2/34) were satisfied with non-segmental fractures with the outcome of treatment.

Table 1: Age and sex variations in study group (*n*=34)

Age	Male	Female	Total
Less than 40	7	1	8
40-60	12	2	14
More than 60	9	3	12
Total	28	6	34

Table 2: Demographics of study and control group (n=34)

Demographics	Study group	Control group
No. Of patients	34	34
Age (years)	42 (16-86)	46 (16-80)
Sex (male/female)	28/6	26/8
Presence of diabetes	2/34	0/34
Classification (AO type)	42C2	42A, 42B
No. Open/closed fracture	15/34	12/34
Gustilo and Anderson grade	Grade I	Grade I
Polytrauma patients	6/34	8/34
Static nail/dynamic nail	22/12	20/14
Reamed (intramedullary nailing)	30	32
Median time to union	160.58 d	110.68 d
Duration of follow-up	12 mo	12 mo

Table 3: Percentage of cases who had unions, malunions, delayed unions, or non-unions in study group (*n*=34)

Fracture healing	Total cases	% of cases
Union	27	79.41 %
Non union	2	5.88 %
Delayed union	5	14.70 %
Malunion	0	0 %

Table 4: Outcome of interlocking nails in both the groups

Results	Study group	Control group
Median time to union	160.58 d	110.68 d
Nonunion	2/34	1/34
Delayed union	5/34	2/34
Superficial infection	5/34	2/34
Limb shortening	3/34	1/34
Excellent	27/34	31/34
Good subjective overall assessment	5/34	2/34
Full satisfaction	27/34	31/34

Fig. 1a: Preoperative anteroposterior and lateral radiograph of segmental tibia fracture (two levels) of 43 y old male

Fig. 1b: Post operative anteroposterior and lateral radiograph of segmental tibia fracture treated with interlocking nail

Fig. 2a: Preoperative anteroposterior and lateral radiograph of segmental tibia fracture (two levels) of 47 y old male

Fig. 2b: Post operative anteroposterior and lateral radiograph of segmental tibia fracture treated with interlocking nail

Table 5: Outcome of results of interlocking nails in study group (*n*=34)

Out comes	No.	%
Excellent	27	79.41 %
Good	5	14.70 %
Poor	2	5.88 %

DISCUSSION

Nonoperative management of a segmental tibial fracture may need a long period of cast immobilization [11]. Fixation with plate and screws requires a large incision with stripping of the contused soft tissues, with a substantial risk of skin necrosis and deep infection. Kuntscher intramedullary nailing can neither give enough rotational stability nor correct the length of tibia.

An interlocking nail has replaced the deficiencies of plating and kuntscher nailing, the fractures can be stabilized immediately and early ambulation becomes possible [12]. Majority of the segmental tibial shaft fractures, by their problematic healing process take prolong time to union and hence increased rates of delayed and nonunion. These statements were taken from the previous literatures. The objective of this study was to confirm where the healing process of segmental tibial fractures differs from that of nonsegmental fractures by comparing a group of segmental tibial fractures with a matched group of nonsegmental tibial fractures treated according to the same protocols. All radiographs in both patient groups were evaluated by using the same criteria. Our observations emphasize the relatively long time required for union to occur in cases of segmental tibial fractures as suggested in the available literature [13-16] We found that the time to union of segmental fractures differed from that of a matched group of nonsegmental fractures. In our study, segmental tibial fractures were united between 16 to 24 w which were similar with the union times of segmental tibial fractures reported in the literature ranging from 15 to 43 w [12, 16, 27] Wide variation in the union time explained and defined in the separate studies. Few studies did not define any definition [20, 23] and others used less stringent definitions [17, 24]. Giannoudis *et al.* [12] reported on a population requiring a relatively long time to heal, but their study included large proportion of open fractures, where as sarmiento and latta reported a short time of union but reported on closed segmental tibial fractures [25]. Because open fractures unite slowly than the closed fractures [12, 17, 24] In our study, we showed 12 cases of open fractures of Gustilo and Anderson grade I. Thus close segmental fractures take shorter union time than the open fractures. In this study, we observed that the reamed intramedullary nailing of segmental tibial shaft fractures take shorter union time than the non reamed intramedullary nailing [23]. In this study, we observed that callus formation was earlier in the posterior and lateral parts of the tibia. This had not been reported earlier. As regards consolidation, the sequence was the same. Our view is that more muscular coverage, better vascular supply and less contusion of soft tissue may be the main causes of earlier callus formation and consolidation at the posterior and lateral aspects. We also observed a higher

incidence of complications during the healing process. In segmental tibia fractures, the amount of non-union and delayed union was more than the non segmental tibia fractures. In segmental tibia fractures, the amount of non-union and delayed union was more in the distal fragment than the proximal fragment. Giotakis N. *et al.* present their treatment of 20 patients with segmental tibial fractures, in which 18 patients there was fracture healing, whereas 2 patients the non-union and pseudoarthrosis formation were reported in the distal fracture focus. In one patient the treatment was continued with circular external fixator and in another one with open and autologous bone grafting. In one patient osteomyelitis developed around the wire, so that the replacement and debridement were performed. In three patients, fracture healed with angular deformity [17].

Bonnevialle analysed 49 cases of segmental fracture of tibia and stated that the non-union in proximal metaphyseal focus in 2 cases and distal focus in six cases (4 diaphyseal and 2 metaphyseal). This non-union were successfully revised with a new nail after re-reaming and fibular osteotomy in 2 cases. Segmental tibia fracture treated with an interlocking nail which did not heal were diaphyseal–diaphyseal fractures (n=6) and diaphyseo-distal metaphyseal fractures (n=2). The intermediate segment measured 13.2 cm (mean) for these patients (non-significance difference). [13]In our study, 2 cases of non-union and 4 cases of the delayed union were found in distal focus at the diaphyseo-diaphyseal region of segmental fractures and 1 delayed union at proximal focus at the metaphyseo-diaphyseal junction. Nonunion were not seen in proximal focus at metaphysio diaphyseal junction. These non-unions were successfully treated with bone grafting and fibular osteotomy along with dynamization. Delayed union was successfully treated with dynamization alone. We did not seen osteomyelitis and angular deformity in this study. Mohammed AA *et al.* [26] found the use of uni-plane external fixation with minimal internal fixation to be successful for the management of closed segmented fracture of tibial shaft. Union rate was 85 % with the expected time 12-24 w, 10 % pass to delayed union and 5 % developed non-union. In our study, we had 2 cases (2/34) of non-union. Reported rates of non-union in these fractures differ substantially. 3 % rates of non-union were reported for interlocking nailing [8], whereas others [19,20], Reported non-union rates in upto 1/3rd of the patients treated with different techniques. There are differences in the definitions of non-union in these studies. Our rate of non-union does not differ from rates reported by other authors using similar definitions [1, 13, 14, 24]. The same account for the delayed union, which classified quite variable in studies is reporting on this outcome [1, 3, 24]. Few studies did not specifically address delayed union [13, 17, 19-22], whereas Giannoudis *et al.* [1] used a comparable definition to ours reporting similar rates of delayed union (20 of 27 and 21 of 29 respectively). In our study, there were 14.75 % (5/34) delayed unions in segmental fractures, and 5.88 % (2/34) delayed union in non-segmental fractures which were treated by dynamization. Teraa M [25] observed a larger need for reoperations in the segmental fracture group compared with the nonsegmental fractures, which is likely related to the increased occurrence of problems regarding bone healing and the higher incidence of septic complications in the segmental fractures. The increased rates of Septic complications could be a result of a large amount of preventive fasciotomies performed in the group with segmental fractures. Gutowski stated that tibial shaft fractures with a wedge butterfly segment are often repaired with intramedullary fixation [27]. In our study, we did not found deep infection in a segmental and nonsegmental group of tibia fractures. Superficial infection was seen in 5 cases of segmental and 2 cases of nonsegmental tibia fractures which were subsided with three weeks of antibiotic treatment. I did a direct comparison with a matched group of nonsegmental fractures and observed the problematic healing of segmental tibia fractures suggested in the literature. A potential limitation of our study was the small number of study population. Nevertheless our results are better than those of the previous studies in which other modality of treatment has been used.

CONCLUSION

The close intramedullary interlocking nail in segmental tibial shaft fracture is the treatment of choice, because patient rehabilitation is early, hospitalization is short and it decreases the rate of nonunion, delayed union and malunion. It also decreases the rate of infection in closed fractures when compared with other types of internal fixation, due to the technique of blind nailing without exposure of the fracture site.

CONFLICT OF INTERESTS

Declared none

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