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Clinical and Radiological Outcomes After Surgical Treatment of Lower Limb Fractures in Patients With Spinal Cord Injury

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Abstract

Study Design: Retrospective observational study.

Objectives: To analyze the clinical and radiological outcomes of lower limb fractures following surgical treatment in patients with chronic spinal cord injury (SCI).

Methods: Between January 2003 and December 2015, 102 chronic SCI patients with a lower limb fracture were surgically treated at our hospital. A total of 58 patients met the inclusion criteria and were recruited for final analysis. Patients with 2-stage procedure or incomplete clinical records with lost-to-follow-up were excluded from the study. Patients were divided into 2 groups (group 1= internal fixation; group 2 = external fixation). Primary outcome measures were to identify the number of nonunions via Kaplan-Meier analysis and the time to bone consolidation. The diagnosis of a pseudarthrosis was made after more than 180 days of consolidation time. Considering the Kaplan-Meier analysis, pseudarthrosis was interpreted as treatment failure. Secondary outcome measure was to evaluate the complication rate with special focus on heterotopic ossification.

Results: A total of 58 chronic SCI patients with closed bone fractures were included in this study. Fifty-two fractures (88%) were simple and 7 (12%) were complex (type C) fractures according to AO classification. The majority of patients (34 cases, 59%) developed femur fractures followed by 24 tibial fractures (41%). Seventeen patients received an external (29%) and 41 an internal fixation (71%). Bone consolidation was reported in 31 patients (53%) with a mean time interval of bone consolidation after 97 days (range from 45 to 160 days; SD = 30). The reported nonunion (pseudarthrosis) rate was 47%. Comparing the internal group (n = 15 patients) versus the external group (n = 14), we could not find any significant difference (P = .939) concerning the bone consolidation time. The Kaplan-Meier analysis showed a 75% cumulative survivorship at 120 days (internal group) versus 111 days (external group). Most common postoperative complications occurred in the internal fixation group with Wound infections being predominantly observed (10%), followed by heterotopic ossifications (8%).

Conclusions: Our results show that surgical treatment of lower limb fractures in chronic SCI patients is a challenging treatment with a high pseudarthrosis rate in both groups. The complication rate seems to be lower in the patients treated with external fixation. As a clinical recommendation, longer implants should be used for a stable osteosynthesis since SCI patients seem to have a higher load on the osteosynthesis material due to missing sensomotoric feedback.

Keywords

spinal cord injury, heterotopic ossification, femur fracture, tibia fracture, open reduction and internal fixation (ORIF), internal external fixation

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Introduction

Patients with spinal cord injury (SCI) used to be a special clientele with a modified lifestyle, frequently occurring complications like pressure ulcers or urinary tract infections.[1] Nowadays, SCI patients are as independent as possible, wheelchair-approved and better rehabilitated.[2] Depending of the neurological type of deficit, para- or tetraplegia and American Spinal Injury Association (ASIA) Impairment Scale (AIS) score, the average life span of an SCI patient is nearly as long as the life expectancy of a non-SCI patient. Middleton et al[3] reported of an estimated life expectancy from 25 to 65 years after SCI occurrence, ranged between 97% to 96% for an AIS D lesion. Nevertheless, despite the high life expectancy, due to the immobility the bone quality of SCI patients is obviously lower compared with non-SCI patients with a higher fracture risk.

Nottage et al give an extensive review of the historical development of bone fractures in SCI patients.[4] They well describe the philosophical change of a conservative to a surgical treatment for fractures on the extremities in patients following SCI. Staub[5] and Meinecke et al[6] started using a conservative treatment with a high complication rate. They logically urged for a surgical treatment with internal fixation. This procedure was improved and expanded by McMaster and Stauffer et al[7] by establishing an open reduction and internal fixation (ORIF). After this change of treatment, the outcome for extremity fractures in SCI patients improved.

However, looking into the literature, we can only find a few articles with small patient collectives presenting the outcomes after operative treatment of lower limb fractures.

In contrast to previous studies, the strength of the present study is the high number of included patients. The main objective of the present study is to analyze the clinical outcome of lower limb fractures with special focus on complications and the prevalence of malunions or nonunions in patients following SCI. We hypothesized that patients with an SCI had a delayed fracture healing or a higher prevalence of malunion or nonunion compared with the reported non-SCI patient results.

Methods

The study was conducted after obtaining approval from our institutional review board all conclusive. Spinal cord injured patients between January 2003 and December 2015, who have received an external or internal bone fixation following a lower limb fracture were enrolled in this study.

Patients younger than 18 years, a conservative fracture treatment, surgical treatment in an outside hospital, missing clinical records with lost-to-follow-up and patients without SCI were excluded from final analysis. A 2-stage treatment protocol was also an exclusion criterion. A total of 102 SCI patients with a lower limb fracture were treated in the Unit of Spinal Cord Injuries at our hospital. Of these, 58 patients met the inclusion criteria.

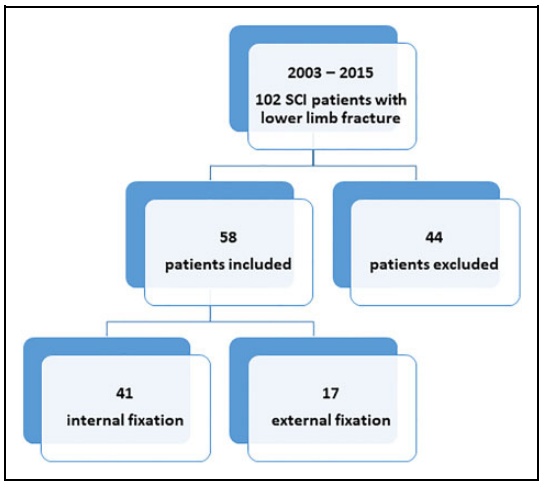

Figure 1. Flowchart of patients' recruitment.

The patient medical records provide the following information: age, gender, type of neurological deficit according to the AIS,[8] date of trauma, cause of trauma, date of hospital admission, type of fracture according to AO classification,[9] date of surgery, operative treatment with type of implant, number of surgeries, length of hospital stay, Charlson comorbidity index,[10] muscle grading for the strength in the injured extremity according to the British Medical Research Council, intensive care unit stay, and peri- and/or postoperative complications such as compartment syndrome, wound healing problems, deep vein thrombosis, pulmonary embolism, pneumonia, heterotopic ossification, or mortality rate.

Outcome Measures

Primary outcome measures were to identify the number of nonunions and the time to bone consolidation. Therefore, we used a Kaplan-Meier analysis with pseudarthrosis judged as treatment failure. Diagnosis of pseudarthrosis was made after more than 180 days of bone consolidation time and made via X-ray and CT-scan. Secondary outcome measure was to evaluate the complication rate with special focus on heterotopic ossification.

The patients were divided into 2 groups: internal fixation (group 1) and external fixation (group 2) (Figure 1). The date of bone consolidation was evaluated until plain radiographs that were taken during the routine outpatient clinic follow-up examinations.

Fracture union was taken as callus bridging of at least 3 cortices on 2 different radiographic views at the fracture site.[11]

Statistical Analysis

Descriptive statistics are presented in the form of number of occurrences and percentage, or mean, standard deviation (SD), and range. All data was processed using a statistical analysis software (Statistica, Version 13.2, Tulsa, OK, USA). Kaplan-Meier survival analysis was performed with the diagnosis of

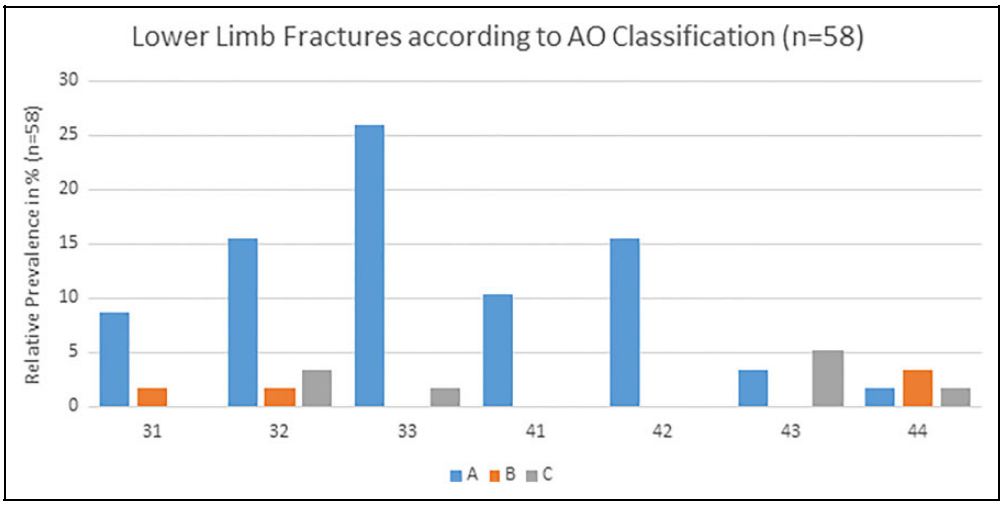

Figure 2. AO fracture classification and prevalence (n = 58).

pseudarthrosis as a primary end point. Confidence interval was set at the 95%.

Results

Fifty-eight SCI patients with lower extremity fractures were enrolled in this retrospective study. The patient cohort consists of 45 paraplegic (78%) and 13 tetraplegic patients (22%) with a mean age of 60 years (range 31-84 years; SD = 15). Forty-four patients were male (76%) and 14 patients were female (24%). Forty-one out of 58 patients (71%) had a complete lesion according to the AIS (AIS A), 5 patients (9%) had an AIS B lesion, 11 patients (19%) had an AIS C lesion, and 1 patient (2%) had an AIS D lesion.

The most common cause for trauma was a simple fall (37 patients, 64%), for example, fall out of the wheelchair or trauma within a transfer from bed to wheelchair. The mean Charlson comorbidity index was 1.01 (0-6; SD = 1.39).

Outcome Measures

The study cohort consists of 58 closed fractures. Fifty-two (88%) are simple- (type A or B) and seven (12%) are complex (type C) fractures according to AO classification. Among these, 34 patients had femur fractures (59%) and 24 had tibia fractures (41%). A detailed information about the fractures with AO classification is presented in Figure 2. All these fractures have been treated operatively. Seventeen patients received an external (29%) and 41 an internal fixation (71%). For internal osteosynthesis we mainly used plates (NCB, LISS, dynamic hip srew, LCDC, TomoFix. In 2 cases, we used a proximal femoral nail. Time interval from date of trauma to date of surgery was 4.2 days (range 0-23 days; SD = 4.5). Time interval from date of surgery to bone consolidation was 97 days (range 45-160 days; SD = 30) with a diagnosed pseudarthrosis in 27 patients (47%). Mean bone consolidation in external osteosynthesis group (n = 14) was 94 days (range 49-150 days) versus 99 days (range 45-160 days) in the internal

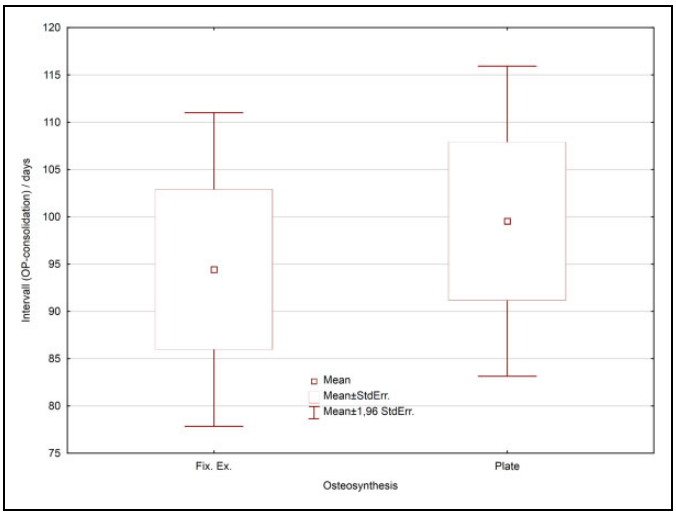

Figure 3. Bone consolidation in dependence of surgical treatment in groups (Fixateur externe [n = 14] vs plate osteosynthesis [n = 15]), cases with diagnosed pseudarthrosis excluded.

osteosynthesis group (n = 15; P = .939; Figure 3). The Kaplan-Meier analysis showed a 75% cumulative survivorship of 111 days (external fixator) versus 120 days (internal fixation; Figure 4).

Most common postoperative complications occurred in the internal fixation group with wound infections being predominantly observed (10%), followed by heterotopic ossifications (8%). Further information about clinical complications are given in Figure 5. An intensive care unit stay was necessary in 5 cases, none of the patients deceased.

Discussion

To the authors' best knowledge, the present study is one of the largest retrospective clinical studies analyzing the outcome of lower limb fractures in SCI patients treated with internal or external fixation. Drennan et al[12] analyzed a cohort of 25

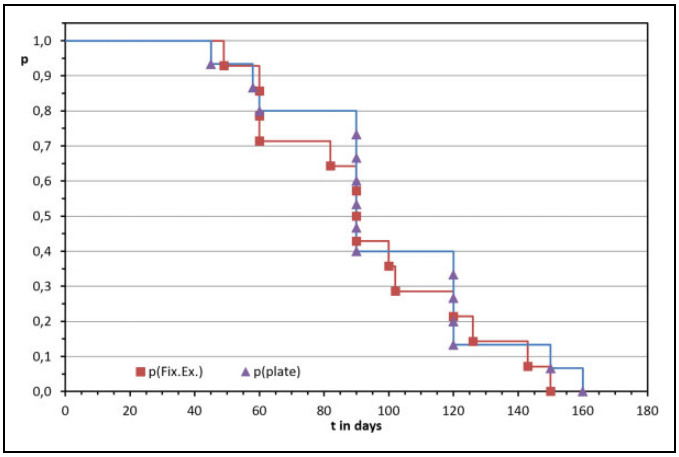

Figure 4. Kaplan-Meier survivorship (n = 58).

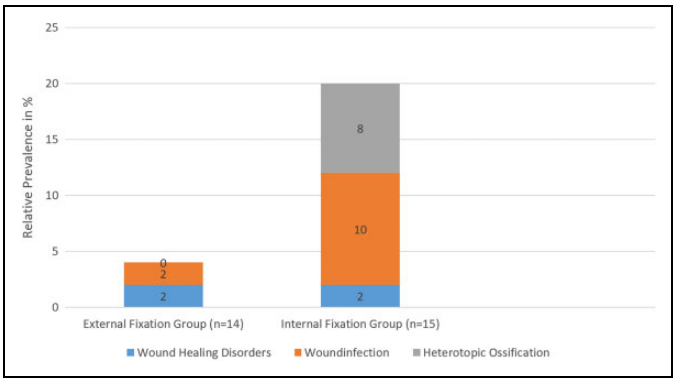

Figure 5. Clinical complications presented in groups.

children treating 58 lower limb fractures by nonoperative treatment. In this study, the main treatment consisted of bilateral long leg braces, which maintained functional alignment and rotation. Complications like leg length discrepancy, bowing deformity and angulation, rotational deformities, and nonunion were described to be well known without mentioning exact numbers.

Sobel et al[13] presented a case of a supracondylar femur fracture of a 43-year-old SCI patient, which was treated nonoperatively by a circular plaster cast. The patient had persistent leg pain. In further diagnostics, a posterior subluxation of the proximal femur with penetration of the bony spike into Hunter's canal was seen. The therapeutic consequence was an above-the-knee-amputation. In their following literature analysis, no clear strategy for bone fractures in SCI patients was given.

In contrast, Garland et al[14] published a review in which they summarized that fractures of extremities in SCI patients should be treated operatively except for tibial fractures. In these cases, they report the outcome to be similar between operative and nonoperative treatment. Furthermore, the numbers for bone malunion or nonunion differ from 31% (femur)[15] to 50% (tibia).[16]

Concerning the operative treatment of lower limb fractures, there are several studies giving results of different surgical techniques. Schmeiser et al[17] treated 20 fractures around the knee joint via retrograde nailing. Despite a radiological osteoporosis in all patients, a bony consolidation was observed after 11 months on average.

A different surgical technique for lower limb fractures was published by Meiners et al[18] who treated 21 patients by external ring fixator. In their analysis, a bony consolidation was radiologically confirmed after 68 days on average. Furthermore, two patients had a loss of extension in the knee joint of 10° after tibial shaft and distal tibia fracture. In their final radiological examination, five patients showed a malalignment after ring fixator removal.

In 2012, Sugi et al[19] successfully treated 11 cases either by ORIF or by intramedullary nailing. The interesting fact of that study is that patients reached the initial life quality measured by the performed questionnaires.

In a recent study, Fouasson-Chailloux et al[20] published an analysis comparing surgical versus non-surgical treatment of lower limb fractures in SCI patients. In their collective of 59 fractures, the authors recommended a surgical treatment for these osteoporotic fractures.

The advantage of our study is on one hand the analysis of 2 different surgical techniques for fractures treatment in SCI patients. On the other hand, the presented study includes all current surgical techniques that are valid for fracture treatment of non-SCI patients. Under these, fracture treatment by external osteosynthesis shows the fastest bone consolidation even if it is not significant. Furthermore, our analysis shows that most of the fractures in SCI patients are simple fractures according to AO classification type "A." One explanation might be that most trauma reason was a simple fall, which is not surprising considering the well-known scenario of severe osteoporosis of SCI patients.[21,22]

A limitation of our study is the retrospective study design, which does not allow for causality to be inferred. Furthermore, we have a very low patients' compliance concerning the follow-up examinations, which predominantly occurred in the internal fixation group. From 44 excluded patients for lost-to-follow-up, we had 34 cases in the internal fixation group (77%).

In conclusion, lower limb fracture treatment in SCI patients should be adapted to the standards of non-SCI patients considering the operative indications, which includes all the biomechanical know-how especially in regard to a severe low bone mineral density. Second, the missing sensomotoric feedback of the lower limb in SCI patients leads to a higher load on the osteosynthesis material due to a longer biomechanical momentum. To address this problem properly, longer implants should be used for a stable osteosynthesis.

Third, in the present study, we analyzed the secondary loss of fracture reposition (LFR). In the internal fixation group, we had 1.3 mm LFR (range 0-7.1 mm; SD = 1.73) and in the external fixation group we had 1.1 mm LFR (range 0-6.7 mm; SD = 2.3) at date of final follow-up.

Finally, the postoperative treatment should contain frequently done clinical and radiological examination to prevent

complications like wound healing disorders or missing fracture consolidation. As a result of the missing sensomotoric feedback of the lower limb in SCI patients, these people may not be able to notice such complications themselves. This may also be the reason for an aggravated postoperative follow-up as we had to experience ourselves in trying to perform this study.

Because of these facts, this information should be assumed by all hospitals treating SCI patients. Concerning the surgical recommendations, the external osteosynthesis impresses with lower complication rates and fast consolidation time.

Declaration of Conflicting Interests

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