

# Long-term functional outcome and quality of life after successful surgical treatment of tibial nonunions

Florian Wichlas · Serafim Tsitsilonis · Alexander C. Disch ·  
Norbert P. Haas · Christian Hartmann · Frank Graef ·  
Philipp Schwabe

Received: 28 November 2014 / Accepted: 1 December 2014 / Published online: 20 December 2014  
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## Abstract

**Purpose** Our aim was to evaluate quality of life (QoL) and functional outcome of patients with tibial nonunions after completion of surgical treatment with an average follow-up of five years.

**Methods** The following data of 64 patients were retrospectively evaluated: fracture type, type and duration of surgical therapy, range of motion of the knee and ankle and American Orthopaedic Foot and Ankle Society (AOFAS) score. QoL was evaluated with the Short-Form Health Survey (SF-36) questionnaire; pain intensity, patient satisfaction and impairments of daily, professional and sport activities with a ten point visual analogue scale.

**Results** QoL, even in cases with successfully completed treatment, was significantly reduced compared with the normal general population. Pain intensity and limited ankle dorsal extension, despite the absence of intra-articular fractures, were significantly correlated with inferior QoL.

**Conclusions** This study emphasises the long-term negative impact of tibial nonunions on patient QoL, even after successful surgical treatment.

**Keywords** Tibia · Nonunion · Quality of life · Fracture · Complication

## Introduction

Skeletal nonunions represent a major problem for patients, the treating orthopaedic surgeon, the public health system and society in general. Long treatment duration, high costs, and work and social implications for these patients can complicate fracture treatment [1, 2]. Nonunions are a possible complication in up to 5 % of all fractures, but the tibia represents the most common site for the development of nonunions [3].

Since managing nonunions can be a therapeutic challenge, a series of treatment options are thoroughly described in the literature [3–6]. The treatment regime aims at successful bone healing and adequate soft-tissue coverage, which may be achieved by a great variety of interventions [7–9]. The short- and midterm surgical outcome is being evaluated in most cases in terms of bone union, range of motion (ROM), infection rate and loss of strength. Several studies show the effectiveness of available treatment options in terms of outcome [10–12]. Nevertheless, over the long term, a certain degree of disability in terms of ROM, persistent pain and other functional limitations can remain, even in cases in which the primary treatment goal has been achieved.

While the existing treatment options and their midterm outcome are thoroughly described in the literature, limited data exist on the long-term quality of life (QoL) and functional outcome of patients after treatment for tibial nonunions.

The aim of our study was to evaluate the long-term health-related QoL (HR-QoL) of patients with tibial nonunions after completion of treatment and to evaluate their functional outcomes.

## Methods

All patients with extra-articular tibial nonunions who were treated operatively in our institution over a ten year period

F. Wichlas · S. Tsitsilonis (✉) · A. Disch · N. P. Haas ·  
C. Hartmann · F. Graef · P. Schwabe  
Center for Musculoskeletal Surgery, Charité - Universitätsmedizin  
Berlin, Augustenburger Platz 1, 13353 Berlin, Germany  
e-mail: serafeim.tsitsilonis@charite.de

S. Tsitsilonis  
Berlin-Brandenburg Center of Regenerative Therapies, Charité -  
Universitätsmedizin Berlin, Berlin, Germany

(2002–2012) and whose treatment was considered completed were included and retrospectively evaluated. Inclusion criteria were patients with completed successful treatment who were older than 18 years and contractually capable. Completed successful treatment was defined as full bone consolidation with uneventful soft-tissue healing. A total of 72 patients with tibial nonunions were identified; 64 entered the study. For the remaining eight patients, treatment was either defined as not successful [persistent and constant soft-tissue fistula ( $n=2$ ), amputation ( $n=4$ )] or not completed [no wish for further medical treatment ( $n=2$ )]. Mean patient age was 42.8 [standard deviation (SD) 15.6; range 19–78] years, with a mean body mass index (BMI) of 26.1 (SD 4.1). The majority of patients were men [ $n=49$  (76.5 %) vs  $n=15$  (23.6 %)], with most being nonsmokers ( $n=38$ ; 59.3 %). Mean follow-up was 61.2 (SD 28.9; range 15–117) months. Nonunions were infectious in 30 cases (46.9 %), atrophic in 19 (29.7 %) and hypertrophic in 15 (23.4 %). The majority of fractures were initially open (56.3 %). An initial nerve lesion was present in four cases (6.3 %). The most common mechanisms of injury were motor vehicle accidents (37.6 %), falls from a significant height (15.6 %), falls from a standing height (14.1 %) and sports injuries (14.1 %). Most patients ( $n=38$ ; 59.4 %) were initially treated in another hospital and were then referred to our institute for further treatment. Left and right sides were equally affected. The following parameters were analysed: fracture classification according to the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA), implant initially used, type of osteosynthesis used to treat the nonunion, number of surgeries, duration of nonunion therapy, application of cancellous bone graft (autologous/allogenic), additional use of recombinant growth factor [bone morphogenetic protein (BMP)], soft-tissue coverage according to the reconstructive ladder, amputation, involved bacteria in cases of infectious nonunions, type and duration of antibiotic treatment and leg-length discrepancy. Knee and ankle-joint ROM and functional status of the ankle [American Orthopaedic Foot and Ankle Society (AOFAS) score; 0–100 points] was recorded. HR-QoL was evaluated using the Short-Form-36 Health Survey (SF-36) [13, 14]. Pain intensity, patient satisfaction with surgical outcome and overall treatment, as well as impaired activities of daily living and of job or sports were further assessed using a ten point visual analogue scale (VAS).

Continuous variables are expressed as mean  $\pm$  SD and categorical variables as percentages (%). The Kolmogorov–Smirnov test was used to assess normality. For parametric variables, Student's  $t$  test was used to compare groups; for nonparametric variables, the Mann–Whitney test was used. Differences for categorical variables were assessed using the  $\chi^2$  or Fisher's exact test between groups. Correlations were examined with either the Pearson product moment correlation coefficient or Spearman's rank correlation coefficient.

**Table 1** Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) fracture classification

Fracture type	Location		
	AO 41	AO 42	AO 43
A	2 (3 %)	14 (22 %)	23 (36 %)
A1	0 (0 %)	3 (4.7 %)	4 (6.3 %)
A2	1 (1.5 %)	4 (6.3 %)	5 (7.7 %)
A3	1 (1.5 %)	7 (11 %)	14 (22 %)
B	0 (0 %)	6 (9.3 %)	0 (0 %)
B2	0 (0 %)	5 (6.3 %)	0 (0 %)
B3	0 (0 %)	2 (3 %)	0 (0 %)
C	0 (0 %)	19 (29.7 %)	0 (0 %)
C1	0 (0 %)	6 (9.3 %)	0 (0 %)
C2	0 (0 %)	6 (9.3 %)	0 (0 %)
C3	0 (0 %)	7 (11 %)	0 (0 %)

Differences were considered to be statistically significant if the null hypothesis could be rejected with >95 % confidence ( $p<0.05$ ).

## Results

### Surgical characteristics

Fracture classification according to AO/OTA is depicted in Table 1. The most common initial surgical treatment was open reduction and internal fixation (ORIF) with plate osteosynthesis ( $n=34$ / 53.1 %), followed by clamp and rod internal fixation (CRIF) and intramedullary (IM) nailing ( $n=28$ ; 43.7 %). The final surgical treatments for nonunions were Ilizarov external fixator ( $n=24$ ; 37.5 %), plate osteosynthesis ( $n=24$ ; 37.5 %), IM nailing ( $n=10$ /15.6 %) and debridement

**Table 2** Scores for different aspects of the Short-Form Health Survey (SF-36)

Concept	Normal population (age 45–65 years)	Study population ( $n=64$ )	$P$ value
Physical functioning (I)	79.1 $\pm$ 22.4	64 $\pm$ 31	<0.001
Role limitations due to physical health (II)	74 $\pm$ 37.6	64 $\pm$ 45	0.08
Role limitations due to emotional problems (III)	84.8 $\pm$ 28.5	74 $\pm$ 43	0.049
Energy/fatigue (IV)	57.7 $\pm$ 18.7	51 $\pm$ 22	0.018
Emotional well-being (V)	68.8 $\pm$ 18.5	64 $\pm$ 25	0.13
Social functioning (VI)	83 $\pm$ 22	76 $\pm$ 27	0.04
Pain (VII)	58.5 $\pm$ 25.8	65 $\pm$ 30	<0.001
General health (VIII)	62.7 $\pm$ 18.8	61 $\pm$ 25	0.59

**Table 3** Significant correlations between Short-Form Health Survey (SF-36) parameters, American Orthopaedic Foot and Ankle Society (AOFAS) and visual analogue scale (VAS) scores, and pain, treatment duration and dorsal extension in the upper ankle joint

	VAS											AOFAS				
	I	II	III	IV	V	VI	VII	VIII	Surgical outcome	Satisfaction	ADL	Sport				
Pain (VAS)	$r = -0.477$ $p = 0.001$	$r = -0.492$ $p = 0.001$	$r = -0.422$ $p = 0.004$	$r = -0.584$ $p < 0.001$	$r = -0.608$ $p < 0.001$	$r = -0.441$ $p = 0.003$	$r = -0.724$ $p < 0.001$	$r = -0.408$ $p = 0.006$	-	$r = -0.328$ $p = 0.032$	$r = 0.54$ $p < 0.001$	$r = -0.566$ $p < 0.001$	$r$			
Duration																
DE ankle																

*I* physical functioning, *II* role limitations due to physical health, *III* role limitations due to emotional problems, *IV* energy/fatigue, *V* emotional well-being, *VI* social functioning, *VII* pain, *VIII* general health, *ADL* activities of daily living, *DE* ankle dorsal extension in the upper ankle joint, *Duration* length of treatment

of the nonunion site with additional bone grafting but without interchanging fixation type ( $n=6$ ; 9.4 %). The mean number of surgeries was 4.85 (SD 4.8), with a mean therapy duration of 2.69 (SD 1.9) years—significantly longer for the infectious nonunion group [mean 3 (SD 1) years;  $p < 0.05$ ]; mean number of operations was eight vs. three in the other groups;  $p < 0.05$ ). In 40 cases (62.5 %), cancellous bone grafting was performed (autologous  $n=28$ ; 43.8 %; allogenic  $n=12$ ; 18.8 %), from which 22 cases (34.4 %) received additional application of growth factors (BMPs). In 30 cases (47 %), surgical soft-tissue coverage had to be performed (Meshgraft  $n=17$ ; 26.6 %; pedicled muscle flap  $n=13$ ; 20.3 %). The need for soft-tissue coverage was significantly higher for patients with infectious nonunions ( $p < 0.05$ ), in which the most commonly involved bacteria were *Staphylococcus aureus* and *S. epidermidis*; in most cases, patients were treated with a combination of amoxicillin/sulbactam for a mean of 3.5 (SD 12.7) months.

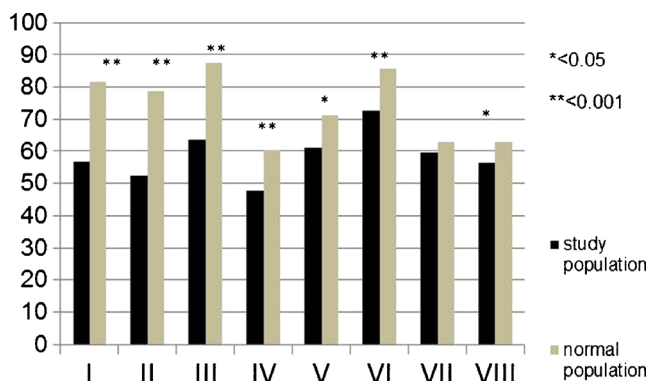
**Functional outcome**

Mean leg-length discrepancy of the affected lower extremity was  $-1.45$  cm (SD 0.7), mean knee flexion and extension was  $117.5^\circ$  (SD 21.7) and  $5^\circ$  (SD 3.3), respectively, and mean ankle dorsal extension and plantar flexion was  $9.75^\circ$  (SD 8.8) and  $26^\circ$  (SD 17), respectively. Mean AOFAS score was 74.9 points (SD 21). Patients with infectious nonunions showed the lowest mean AOFAS scores [68 points (SD 21)] compared with patients with atrophic [76 points (SD 13)] and hypertrophic [87 points (SD 25)] nonunions. However, these differences were not statistically significant.

**Quality of life and patient satisfaction**

The evaluation of HR-QoL issues in terms of the SF-36 questionnaire were compared to the age-matched (45–65 years), normal general population (Table 2) [14]; the study population showed statistically significantly inferior values. Mean pain intensity according to the VAS was 2.8 (SD 2.3) points, and mean VAS for patient satisfaction with the surgical outcome was 8.2 (SD 2.7) points and with overall treatment 8.2 (SD 2.4) points. Mean VAS for impairment in activities of daily living and professional and sport activities were 4 (SD 3.2) and 4.8 (SD 3.4) points, respectively.

Highly significant negative correlations ( $p < 0.001$ ) were observed between pain intensity and all subgroups of the SF-36 questionnaire and with AOFAS and VAS scores for patient satisfaction and impairments in daily living and professional and sport activities. Additionally, a positive correlation between the degree of dorsal extension in the ankle and general health SF-36 subgroup was observed ( $\rho = 0.461$ ;  $p = 0.035$ ). SF-36 scores also showed negative correlations between overall therapy duration and patient



**Fig. 1** Health-related quality of life (HR-QoL) as evaluated with the Short-Form Health Questionnaire (SF-36) of patients, and the general normal population aged 45–65 years old. Study population QoL was significantly inferior, with the exception of pain. *I* Physical functioning, *II* role limitations due to physical health, *III* role limitations due to emotional problems, *IV* energy/fatigue, *V* emotional well-being, *VI* social functioning, *VII* pain, *VIII* general health

satisfaction with surgical outcome ( $\rho = -0.448$ ;  $p = 0.003$ ), physical functioning ( $\rho = -0.349$ ;  $p = 0.04$ ) and role limitations due to emotional problems ( $\rho = -0.328$ ;  $p = 0.032$ ) (Table 3).

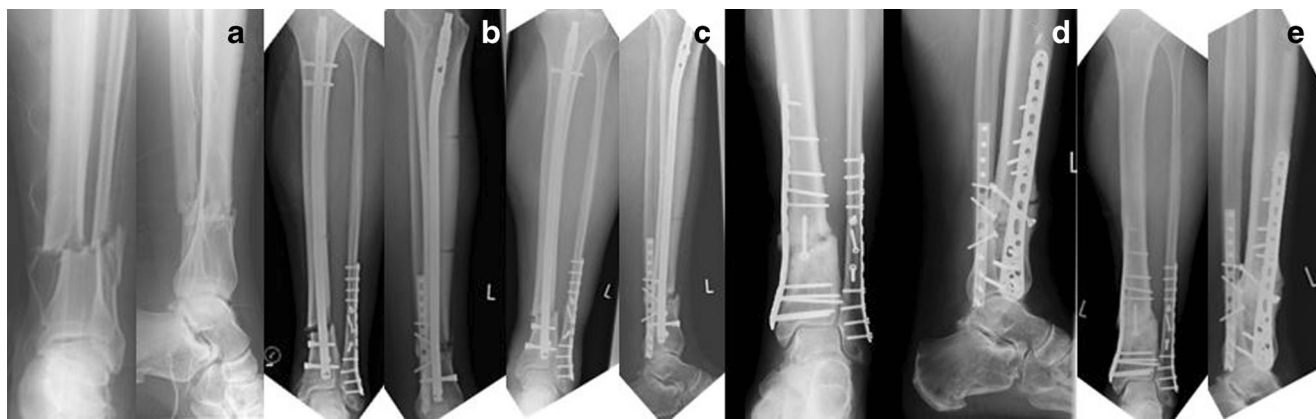
## Discussion

Treating tibial nonunions is a therapeutic challenge for the orthopaedic surgeon. Several treatment options have been described in the literature, with rigid fixation and bone grafting being considered the gold standard [3, 4, 15]. By those means, bone union and adequate soft-tissue coverage can be achieved in the majority of cases, even in cases of infectious nonunions [2, 10, 16–18]. However, treatment is often highly time and resource consuming [19]. This study

shows the long-term detrimental effects of tibial nonunions on patient QoL, even in cases of completed surgical treatment with supposedly successful outcome in terms of bone union and soft-tissue coverage. QoL of those patients was significantly inferior compared with the age-adjusted normal population [14]. VAS evaluation showed relatively mild pain, with acceptable patient satisfaction in terms of surgical outcome and overall treatment. Nevertheless, professional and sport activities were affected in everyday life for the majority of patients.

To our knowledge, this is the first study that evaluates the long-term effect of tibial nonunions on patient QoL at a mean follow-up of five years after completion of therapy. Every aspect of the QoL of the study population was decreased, as evaluated by the SF-36. Physical health-related and emotional problems were the main factors leading to the reduction in everyday QoL. Overall treatment duration correlated with lower patient satisfaction and increased limitations due to physical functioning and emotional problems. However, pain intensity seemed to be the main factor that correlated with decreased QoL. These results are in accordance with previous studies: Brinker et al. showed the detrimental effects on HR-QoL of tibial nonunions during treatment [11]. In a subpopulation of older patients treated with Ilizarov external fixation, there was a midterm improvement in QoL after completion of therapy; however, scores were still inferior compared with the normal population [20]. Zeckey et al. observed a deterioration in patient QoL after completed treatment of tibial nonunions [12], but the length of follow-up was not reported. Bowen et al. reported similar results to results of our study in a small population (eight patients) of infectious tibial nonunions [21].

While in our population knee ROM was not significantly affected, a certain limitation was observed in patient mobility in the ankle joint. Limitation of the dorsal extension in the ankle showed a significant negative correlation with general



**Fig. 2** **a** Initial X-rays of a male patient, 50 years old, with an open tibia fracture of Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) type 42B3; **b** treatment with intramedullary (IM) nailing and open reduction and internal fixation (ORIF) of the fibula five days after initial treatment with external fixator

(X-rays not shown); **c** dynamization of IM nailing due to delayed healing five months after treatment; **d** revision of the osteosynthesis 18 months after trauma, with nail removal, debridement, autologous cancellous bone graft, bone morphogenic protein (BMP)-7 application and plate and lag-screw osteosynthesis; **e** successful healing two years after trauma

health, as evaluated with the SF-36. The decreased AOFAS scores confirmed limitations in ankle movement, even though no patient with intra-articular injuries was included in the study. Additionally, AOFAS score correlated with patient satisfaction, impairments of daily living and impairments associated with professional and sport activities, further emphasising the importance of the ankle joint for restoration of activities of daily living. Shahid et al. reported higher AOFAS scores in the short-term follow-up compared with our study population [10]. This could be attributed to the lower number of surgeries and shorter overall treatment duration and follow-up.

Additionally, limitation in dorsal extension of the ankle further correlated with limitation of activities of daily living and with general health as assessed using the SF-36. These results emphasise the fact that bone union in combination with successful soft-tissue coverage should be the primary goal in treating such patients, despite the fact that this could result in long treatment duration and repeated surgeries. Moreover, limitation in ankle-joint ROM, possibly resulting from immobilisation and scar tissue formation, need to be addressed during postoperative care. Our patients showed a mean dorsal extension in the ankle of  $<10^\circ$ . This seems to be a major limitation for everyday living, as simple activities, such as stair climbing and walking on uneven surfaces, is significantly adversely affected.

In conclusion, our study emphasises the long-term negative impact of tibial nonunions on patient HR-QoL, even in cases of successful surgical treatment. While the goal of treatment still is bony union and soft-tissue coverage, the importance of the initial treatment of tibia fractures, also aimed at reducing the risk of nonunion, should be a crucial part of the treatment strategy. Figs. 1 and 2

**Conflict of interest** None.

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