ORIGINAL ARTICLE

Acta Orthop Traumatol Turc 2013;47(1):19-26
doi:10.3944/AOTT.2013.2823

Limb salvage and amputation in Type 3C tibial fractures

Tahir Sadık SÜGÜN, Kemal ÖZAKSAR, Tulgar TOROS, Murat KAYALAR, Emin BAL, Fuat ÖZERKAN

Hand Microsurgery Orthopaedics and Traumatology (EMOT) Hospital, İzmir, Turkey

Objective: The aim of this study was to evaluate the results of limb salvage and primary amputation treatments in patients with Type 3C tibia fractures and compare with normative population data.

Methods: Limb salvage was performed in 20 patients and primary amputation in 14 patients with Type 3C tibia fractures between 1993 and 2009. Mean follow-up period was 5.3 years. Treatment times, complications, number of operations and return-to-work status of groups were compared. The Short Form-36 (SF-36) was used to assess quality of life and domains were compared among the patient groups and normative data.

Results: Limb salvage patients had longer treatment periods with more operations and complications than the primary amputation group. Return-to-work percentage was 59% in the limb salvage group and 71% in the amputation group. There was no statistical difference in all SF-36 domains for limb salvage and primary amputation patients. Physical functioning, social functioning, limitation due to emotional problems and pain were statistically lower in all patients than in the general population.

Conclusion: Type 3C tibia fractures treated with both limb salvage and primary amputation have negative effects on quality of life. Patients should be informed about limited functional capacity, pain complications and problems with return-to-work at the end of treatment. In addition, high rates of limb salvage can be achieved with proper conditions in suitable patients.

Key words: Amputation; complication; life quality; limb salvage; tibia; Type 3C fracture.

Type 3C tibial fractures that require arterial repair for the salvage of extremity occupy a special place among severe lower extremity injuries.[1] Circulation problem as well as bone and soft tissue damage make treatment of these fractures particularly difficult. Today, with improvements in bone reconstruction techniques, free tissue transplantation and tissue repair requiring microsurgery, limb salvage procedures can be performed in most C type tibial fractures. However, primary amputation has been reported to be the treatment of choice in Type 3C tibial fractures and other severely injured lower extremities.[2-8] Due to physiological and psychological limitations in patients undergoing limb salvage or primary amputation, arduous and prolonged treatment processes exposed to complications have always been under dispute.[2,6-13]

In this study, we aimed to evaluate the treatment and follow-up processes of patients presenting with Type 3C tibial fractures and undergoing limb salvage or primary amputation. Complications, treatment duration, return-to-work status and physical and psychological quality of life scales were evaluated together with the standards of the general population.

Correspondence: Tahir S. Sügün, MD. El Mikrocerrahi Ortopedi ve Travmatoloji Hastanesi (EMOT) 1418 Sok. No: 14, 35230 Kahramanlar, İzmir, Turkey.

Tel: +90 232 - 441 01 21 e-mail: tssugun@hotmail.com

Submitted: January 25, 2012 **Accepted:** September 24, 2012

Available online at
www.aott.org.tr
doi:10.3944/AOTT.2013.2823
QR (Quick Response) Code:

Patients and methods

A total of 34 patients treated for Type 3C tibial fractures between 1993 and 2009 were enrolled in this study. Patients with additional injury of the extremity in the diagnostic and follow-up period and those with a systemic disease that might lead to physiological and psychological limitations were excluded. Fractures were classified according to the system developed by Gustilo et al.[1] Seventeen of 20 patients undergoing limb salvage (secondary amputation due to vascular insufficiency was performed in one patient and two patients were lost during follow-up), and 14 of 14 patients undergoing primary below-knee amputation were evaluated at the end of a mean follow up of 5.3 years. Patient demographics are detailed in Table 1.

The decision to perform limb salvage or primary amputation was made by a minimum of two experienced orthopaedic surgeons following debridement and irrigation in the operating room under anesthesia. Salvage procedures were preferred in children and adolescents with early presentation, those expected to be productive and functional after limb salvage procedure and those with bone and soft tissue defects who could be treated with modern techniques. Both patient groups and their families were interviewed and informed prior to treatment. Previously reported lower extremity injury scores, presence or absence of plantar sensation or the preservation of the anatomic integrity of the tibial nerve were not considered during decision making.[14-19] Since arterial injury was confirmed by clinical and surgical findings, no patients underwent angiography. Treatments (bone fixations, arterial and nerve repair, free bone and soft tissue transplantations, treatment of complications, amputations) were performed by the same orthopaedic surgical team.

Treatment duration, complications, number of procedures, time to union and prosthesis fitting in primary amputations were recorded during follow-up. At the end of the follow-up period, return-to-work status was categorized as follows: ability to do the same job (complete), ability to work in another job (limited), quitting work due to injury or advanced age (retired/unemployed) and housewives for female patients. Patients undergoing limb salvage were asked whether they would choose the same treatment modality and were satisfied with the outcome in terms of their experience during the moment of injury and the treatment process. The Short Form-36 (SF-36) was used to measure quality of life.[20,21] Eight sub-dimensions including physical functioning (PF), role limitations due to physical problems (RP), pain (P), general health perception (GH), mental health (MH), role limitations due to emotional problems (RE), vitality (V) and social functioning (SF) were evaluated by the patients (Table 2). Patient groups were compared within themselves and with standards of the general population.[22]

Mean and standard deviation were used as descriptive statistics and a t-test was used to compare and interpret group data and standards of the general population. A p value less than 0.05 was considered statistically significant.

Results

Mean follow-up period was 5.3 (range: 2 to 17) years. The treatment duration of patients undergoing limb

Table 1. Demographic data of the patient groups.

Patient group	Limb salvage	Primary amputation
Number of patients	20	14
Men/Women	18/2	12/2
Mean age±SD (min-max)	29.5±12.4 (10-49)	38.1±16.7 (17-72)
Injury mechanism	Vehicle: 8 Labor: 4 Farming: 5 Gunshot: 3	Vehicle: 9 Labor: 4 Gunshot: 1
Fracture site	Proximal: 2 Middle: 5 Distal: 12 Segmental: 1	Proximal: 1 Middle: 6 Distal: 6 Segmental: 1
Mean number of operations (min-max)	6.05 (3-10)	2.21 (1-4)
Complications	21 complications in 14 patients	9 complications in 9 patients
Mean treatment time±SD (min-max) (months)	13.7±7.3 (3-28)	1.1±0.4 (1-2)
Mean follow-up time±SD (min-max) (years)	5.8±4.3 (2-17)	4.7±4 (2-17)

SD: standard deviation

Table 2. SF-36 sub-dimensions and explanations.

SF-36 sub-dimensions	Low score	High score
Physical function	Limitation in all physical activity like dressing or taking a bath	Able to do all physical activities without limitation
Limitation of physical function	Role limitations in work and daily activities due to physical health problems	No physical limitation in work and daily activities
Pain	Severe and limiting pain	Painless or no limitation due to pain
General health perception	Believing in having a bad or worse health	Believing in having an excellent health
Mental health	Emotion of being nervous or in depression constantly	Emotion of being calm, relax and happy
Limitation of emotion	Role limitations in work and daily activities due to emotional problems	No limitation in work and daily activities due to emotional problems
Vitality	Feeling tired and exhausted	Feeling lively and energetic
Social function	Limitations in social activities due to physical and emotional problems	No limitation in social activities due to physical and emotional problems

salvage (average: 13.7 months) was significantly longer than that of patients undergoing primary amputation (average: 1.1 month) ($p<0.05$). During this time period, three times more surgical procedures were performed in patients undergoing limb salvage (Table 1).

Complications during the treatment period determined the treatment duration and number of procedures. In the salvage group, 14 patients had 21 complications. The most common complications requiring surgical intervention were vascularized bone graft fracture, equinism and shortness. All complications were treated at the end of the period with the exception of four complications in four patients. The mean number of procedures per patient was 6.05. The mean duration of bone union was 13.9 (range: 6 to 28) months. In the primary amputation group, for which stump revisions were determinant, the mean number of procedures was 2.2. The stump became suitable for prosthesis with one operation in 4 patients, 2 operations in 4 patients and more than 2 operations in 6 patients. At the end of an average of 2.8 (range: 2 to 7) months, 9 of the patients who started using a prosthesis had amputation stump problems. The most common reason was skin problems. There were statistically significant differences in the number of procedures and treatment duration between two groups ($p<0.05$).

After limb salvage procedure, 5 patients returned to their previous work and 6 patients continued working in the same workplace doing lighter tasks. Five of the remaining 6 patients were unemployed or retired due to injury related limitations. One female patient continued her life as a housewife. In the amputation group, 5 patients returned to work completely and 5 patients returned to work on a limited basis. Two were unemployed or retired and another 2 were housewives (Table 1). All patients undergoing limb salvage reported being content with their legs and would have chosen the same treatment modality over again.

No significant differences were noted between patients undergoing limb salvage and those undergoing primary amputation in the SF-36 sub-dimensions. When compared with standards of the general population, both salvage and amputation groups were significantly affected in the sub-dimensions PF, RP, P, RE and SF ($p<0.05$). Patients in both groups had a similar overall health perception to the general population. Mean mental health of the patients undergoing limb salvage was close to that of the general population. Both patient groups reported feeling more energetic and lively compared to society (Fig. 1 and Table 3). Range of movement of the knee and ankle joint was significantly decreased ($p=0.007$ and $p=0.000$, respectively) compared to the healthy side in the group undergoing limb salvage (Table 4).

Discussion

The treatment of severely injured lower extremities with no blood supply is one of the most disputed issues in trauma surgery. The small number of Type 3C tibial fractures, even in large series, makes it the comparison of the outcomes of limb salvage procedure versus primary amputation more difficult.[2-8,23] In a prospective study of 601 patients admitted to eight Level 1 trauma centers by MacKenzie et al., 14 patients underwent reconstruction and 45 patients underwent amputation for 59 Type 3C tibial fractures.[8] In our series,

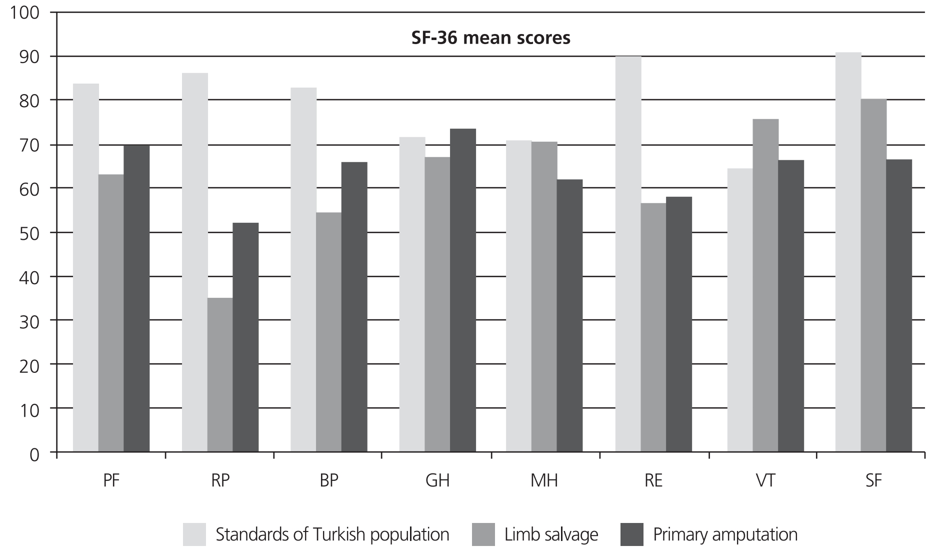

Fig. 1. SF-36 sub-dimensions in patient groups and the population (PF: physical functioning, RP: role limitations due to physical problems, BP: bodily pain, GH: general health perception, MH: mental health, RE: role limitations due to emotional problems, V: vitality, SF: social functioning).

limb salvage was performed in 20 of 34 patients and one patient was treated for secondary amputation due to vascular insufficiency in the early period and 14 were treated for primary amputation.

Severely injured lower extremity scores had low sensitivity and were cumbersome to apply in clinical practice in the determination of initial treatment of patients and prediction of subsequent functional outcomes.[24,25] Plantar sensation at the moment of injury does not provide information related to prognosis in terms of restoration of sensation and long-term functional outcomes. Therefore, plantar sensation is not recommended as a guide in the decision making process for limb salvage procedure.[26] In our study, lower extremity injury scores or the presence or absence of plantar sensation was not used in the process of treatment decision making during the initial patient evaluation. Angiography has been reported to be unnecessary in the diagnosis of arterial injury associated with open fractures and to cause delay in critical arterial repairs.[27-29] Angiography was not performed for vascular injuries in our patients. All arterial injuries were diagnosed in the operating room and planning was conducted based on the treatment modality.

As in severely injured lower extremities, limb salvage procedures require long treatment duration and are exposed to complications in Type 3C tibial fractures.[1,2,4,6,11,12,30,31] In 23 open tibial fractures with associated vascular injuries, Lange et al. reported a per patient average of three operations in patients undergoing primary amputation and seven on patients undergoing reconstruction.[32] A study by Drost et al.

Table 3. Comparison of SF-36 sub-dimensions in population standards, the limb salvage group and primary amputation group (Significant p values are written in bold).

SF-36 sub-dimensions	Population - Limb salvage	Population - Primary amputation	Limb salvage - Primary amputation
Physical function	**p=0.0011**	**p=0.0145**	p=0.4982
Limitation of physical function	**p<0.0001**	**p<0.0001**	p=0.3216
Pain	**p<0.0001**	**p=0.0023**	p=0.3669
General health perception	p=0.38	p=0.6743	p=0.5851
Mental health	p=0.9552	**p=0.0060**	p=0.4808
Limitation of emotion	**p<0.0001**	**p<0.0001**	p=0.9276
Vitality	**p=0.0075**	p=0.6447	p=0.3652
Social function	**p=0.0083**	**p<0.0001**	p=0.3680

Table 4. Comparison of mean±SD joint range of motions (ROM) and tibial lengths with non-operated sides in limb salvage patients.

	Operated side	Non-operated side	P value
Knee ROM (degrees)	118.4±12.7	124.4±11.1	0.007
Ankle ROM (degrees)	25±9.1	59±8.6	0.000
Radiologic tibial lengths (cm)	38.9±4.4	39.9±4.4	0.027

reported long-term major complications (chronic osteomyelitis, non-healing soft tissue wounds, non-unions) in 50% of patients undergoing limb salvage and skin problems and superficial infection in 63% of patients undergoing amputation.[33] In our series, the number of non-healing soft tissue wounds and chronic osteomyelitis was smaller compared to that reported in the literature. We consider that the most important factor, other than those related to the trauma and the patient, is inadequate debridement and delayed closure of soft tissue in problems such as chronic osteomyelitis and non-healing soft tissue wounds. In this study, all operations were carried out by an orthopaedic surgical team performing microsurgery, which we believe reduced the number of complications.[5] Operations performed for complications were the determinant for the number of procedures and treatment duration. After initial treatments, 4 of 21 complications in 14 patients in the salvage group became permanent (Table 5). In the amputation group, stump revisions were the most common reason for operations and 9 patients had skin problems after they started to use prosthesis.

Bosse et al. investigated the return to work rate in 460 patients with severely injured lower extremities and reported 53% in the amputation group and 49.4% in the salvage group with no statistically significant difference.[9] Puno et al. reported return-to-work in 4 of 6 patients undergoing limb salvage procedure and in 5 of 6 patients undergoing primary amputation in Type 3C tibial fractures.[6] At the end of follow up period, 11 of 17 patients in the salvage group and 10 of 14 patients in the amputation group returned to work in our study. We consider that the use of return-to-work as an outcome of this type of injuries is controversial. Patients' job and the injury and the physical requirements of these jobs should be taken into consideration. In addition, some patients had the opportunity to perform different tasks at the same workplace based on their educational status, knowledge and skills, which was not possible for other patients. One of the limitations of this study was that only one question was asked to evaluate patients' satisfaction with their treatment, as in other studies. All patients undergoing limb salvage reported being content with the outcome.

Today, the quality of life of patients after treatment and the status of returning to their normal lives are taken into greater consideration. The SF-36 is the most commonly employed generic scale for measuring quality of life. The scale measures eight dimensions of health using 36 items. It is easy to administer and is filled out by patients themselves. Validity and reliability studies and studies for the determination of population norms were conducted in Turkish.[21,22] However, there is not sufficient evaluative data for Type 3C tibial fractures, which is a rarely addressed issue in the literature. In general, these fractures, together with Type 3 open fractures, have been compared, as a joint salvage group, with the amputation group.[2,7,11] Some authors have reported their results using quality of life instruments other than the SF-36.[3]

In a study by Giannoudis et al.,[3] patients undergoing limb salvage reported problems with pain more frequently than amputees in Type 3C fractures. No significant differences were noted between the two groups in self-care. The amputation group had significantly more limited mobility than the limb salvage group whereas anxiety and depression were more common in the salvage group. In a study using the SF-36 by Dagum et al.,[7] physical function scores were significantly different in favor of the salvage group. No differences were noted in the mental component score. On the contrary, Georgiadis et al. reported that patients undergoing limb salvage experienced more functional limitation than amputees.[4] Bosse et al. found no significant differences between patients undergoing limb salvage versus amputation in physical restrictions.[9] As seen in the literature, the superiority of one treatment modalities over the other cannot be demonstrated in terms of functionality and quality of life.

In our study, there were no significant differences between limb salvage patients and amputees in any sub-dimensions of the SF-36. In parallel to the literature, patients' physical and social functions, emotional status and pain were found to be significantly lower

Table 5. Demographic, treatment and follow-up data of the patients.

Patient no.	Age	Sex	Side	Injury mechanism	Fracture classification (OTA)	Tibial nerve	Revascularization	Reconstruction	Number of operations	Follow-up) years)	Treatment time (months)	Complications (Early- and long-term)	Complication treatment	Remaining/ non-addressed complications	Bony union (months)
1	25	F	L	VI	42B2	Intact	SG (8 cm)	LDF	5	17	21	Nonunion	Ilizarov	None	26
2	14	M	L	FI	43C1	Intact	SG (20 cm)	ROTF	7	12	12	Refracture	Bone graft	None	12
3	19	M	L	FI	42A3	Intact	SG (20 cm)	None	4	11	8	Foot intrinsic contracture	MP joint arthrodesis	MP joint arhtodesis	26
4	35	M	R	LI	41A3	Intact	End-to-end	None	9	10	15	Knee septic arthritis	Arthroscopic lavage	None	7
5	41	F	R	FI	42B3	Intact	SG (13 cm)	None	5	8	8	Implant failure + equinism	Implant revision + Achilloplasty	None	12
6	18	M	R	GI	42B3	Intact	SG (15 cm)	VICG	Lost	Lost	Lost	Graft fracture	Cast	Lost	Lost
7	30	M	L	VI	42B3	Intact	End-to-end	LDF	6	6	6	None	None	None	10
8	45	M	L	GI	41A3	Intact	End-to-end	None	3	5	7	None	None	None	9
9	16	M	R	VI	43C3	Intact	End-to-end	FFOF	6	5	14	Graft fracture + malunion	Cast	Ankle varus	9
10	25	M	L	VI	42C3	Intact	SG (15 cm)	None	5	4	15	Implant failure	Implant revision	None	24
11	10	M	L	FI	42B3	Intact	SG (13 cm)	None	3	4	6	Circulatory insufficiency	Secondary amputation	Below-knee amputation	Amputated
12	46	M	L	FI	42C2	Intact	SG (15 cm)	FFOF	8	3	17	Graft fracture + malunion	Cast	Ankle varus	18
13	43	M	R	VI	43C1	Intact	SG (10 cm)	LDF	7	3	28	Osteomyelitis + nonunion	Resection + Ilizarov	None	28
14	38	M	R	LI	42A2	Intact	SG (10 cm)	None	10	3	20	Equinism	Ankle arthrodesis	Ankle arthrodesis	7
15	12	M	L	VI	42B2	Repair (E)	End-to-end	None	Lost	Lost	Lost	Lost	Lost	Lost	Lost
16	31	M	L	VI	42C2	Repair (G) (5 cm, 4 cable)	SG (15 cm)	FFOF	8	3	23	Early venous insufficiency + equinism + graft fracture + shortness	Venous revision + lengthening + corrective osteotomy	None	12
17	49	M	R	LI	43B2	Intact	End-to-end	ALTF	5	3	8	Forefoot necrosis	Forefoot amputation	Forefoot amputation	8
18	43	M	L	LI	43A3	Repair (E)	End-to-end	ALTF	6	2	22	Equinism + shortness	Achilloplasty + lengthening	None	11
19	26	M	L	VI	43A3	Repair (E)	End-to-end	ALTF	3	2	6	Shortness	None	Shortness	12
20	24	M	L	GI	43C3	Repair (G) (6 cm, 7 cable)	SVF (10 cm)	FFOF	6	2	3	None	None	None	6

ALTF: anterolateral thigh flap; E: end-to-end; F: female; FFOF: free fibular osteocutaneous flap; FI: farming injury; G: graft; GI: gunshot injury; L: left; LDF: latissimus dorsi flap; LI: labor injury; M: male; R: right; ROTF: rotational flap; SG: saphenous vein graft, SVF: saphenous venous flap; VI: vehicle injury; VICG: vascularized iliac crest graft than those of the general population. Vitality was significantly higher than the general population for both groups which we believe to be caused by patients' effort to pretend to be psychologically better than they really were as the patients' functional and physical role limitations do not support this.

The limitations of this study were the differences in age, sex, occupation, types of injury and treatment and functional capacity between the patients and groups that prevent the formation of homogeneous groups and decrease the power of comparative analyses. Standardization of bone and soft tissue injuries and associated treatment modalities, however, is not possible in high energy injuries such as Type 3C tibial fractures.

In conclusion, Type 3C tibial fractures result in adverse effects on patients' quality of life no matter which treatment modality is chosen. Patients presenting with this type of injury should be informed of a more limited functional capacity compared to the general population, pain, possible complications and problems related to return-to-work at the end of the treatment. However, with the provision of appropriate conditions for eligible patients, a high rate of limb salvage can be performed in Type 3C tibial fractures.

Conflicts of Interest: No conflicts declared.

References

1. Gustilo RB, Mendoza RM, Williams DN. Problems in the management of type III (severe) open fractures: a new classification of type III open fractures. J Trauma 1984;24:742-6.
2. Hoogendoorn JM, van der Werken C. Grade III open tibial fractures: functional outcome and quality of life in amputees versus patients with successful reconstruction. Injury 2001; 32:329-34.
3. Giannoudis PV, Harwood PJ, Kontakis G, Allami M, Macdonald D, Kay SP, et al. Long-term quality of life in trauma patients following the full spectrum of tibial injury (fasciotomy, closed fracture, grade IIIB/IIIC open fracture and amputation). Injury 2009;40:213-9.
4. Georgiadis GM, Behrens FF, Joyce MJ, Earle AS, Simmons AL. Open tibial fractures with severe soft-tissue loss. Limb salvage compared with below-the-knee amputation. J Bone Joint Surg Am 1993;75:1431-41.
5. Soucacos PN, Beris AE, Xenakis TA, Malizos KN, Vekris MD. Open type IIIB and IIIC fractures treated by an orthopedic microsurgical team. Clin Orthop Relat Res 1995;(314): 59-66.
6. Puno RM, Grossfeld SL, Henry SL, Seligson D, Harkess J, Tsai TM. Functional outcome of patients with salvageable limbs with grades III-B and III-C open fractures of the tibia. Microsurgery 1996;17:167-73.
7. Dagum AB, Best AK, Schemitsch EH, Mahoney JL, Mahomed MN, Blight KR. Salvage after severe lower-extremity trauma: are the outcomes worth the means? Plast Reconstr Surg 1999;103:1212-20.
8. MacKenzie EJ, Bosse MJ, Kellam JF, Burgess AR, Webb LX, Swiontkowski MF, et al. Characterization of patients with high-energy lower extremity trauma. J Orthop Trauma 2000;14:455-66.
9. Bosse MJ, MacKenzie EJ, Kellam JF, Burgess AR, Webb LX, Swiontkowski MF, et al. An analysis of outcomes of reconstruction or amputation after leg-threatening injuries. N Engl J Med 2002;347:1924-31.
10. MacKenzie EJ, Bosse MJ, Pollak AN, Webb LX, Swiontkowski MF, Kellam JF, et al. Long-term persistence of disability following severe lower-limb trauma. Results of a seven-year follow-up. J Bone Joint Surg Am 2005;87:1801-9.
11. Saddawi-Konefka D, Kim HM, Chung KC. A systematic review of outcomes and complications of reconstruction and amputation for type IIIB and IIIC fractures of the tibia. Plast Reconstr Surg 2008;122:1796-805.
12. Busse JW, Jacobs CL, Swiontkowski MF, Bosse MJ, Bhandari M; Evidence-Based Orthopaedic Trauma Working Group. Complex limb salvage or early amputation for severe lower-limb injury: a meta-analysis of observational studies. J Orthop Trauma 2007;21:70-6.
13. Sutherland AG, Suttie S, Alexander DA, Hutchison JD. The mind continues to matter: psychologic and physical recovery 5 years after musculoskeletal trauma. J Orthop Trauma 2011; 25:228-32.
14. Helfet DL, Howey T, Sanders R, Johansen K. Limb salvage versus amputation. Preliminary results of the Mangled Extremity Severity Score. Clin Orthop Relat Res 1990;(256): 80-6.
15. Howe HR Jr, Poole GV Jr, Hansen KJ, Clark T, Plonk GW, Koman LA, et al. Salvage of lower extremities following combined orthopedic and vascular trauma. A predictive salvage index. Am Surg 1987;53:205-8.
16. Johansen K, Daines M, Howey T, Helfet D, Hansen ST Jr. Objective criteria accurately predict amputation following lower extremity trauma. J Trauma 1990;30:568-72.
17. McNamara MG, Heckman JD, Corley FG. Severe open fractures of the lower extremity: a retrospective evaluation of the Mangled Extremity Severity Score (MESS). J Orthop Trauma 1994;8:81-7.
18. Russell WL, Sailors DM, Whittle TB, Fisher DF Jr, Burns RP. Limb salvage versus traumatic amputation. A decision based on a seven-part predictive index. Ann Surg 1991;213: 473-80.
19. Seekamp A, Köntopp H, Tscherne H. Hannover Fracture Scale '98 – reevaluation and new prospects for an established score system. [Article in German] Unfallchirurg 2001;104: 601-10.
20. Ware JE Jr, Shelbourne CD. The MOS 36-item short-form health survey (SF-36). Conceptual framework and item selection. Med Care 1992;30:473-83.
21. Koçyiğit H, Aydemir Ö, Fişek G, Ölmez N, Memiş A. Reliability and validity of the Turkish version of the Short Form-36 (SF-36). [Article in Turkish] İlaç ve Tedavi Dergisi 1999;12:102-6.
22. Demiral Y, Ergor G, Unal B, Semin S, Akvardar Y, Kivircik B, et al. Normative data and discriminative properties of short form 36 (SF-36) in Turkish urban population. BMC Public Health 2006;6:247.
23. Parmaksizoglu F, Koprulu AS, Unal MB, Cansu E. Early or delayed limb lengthening after acute shortening in the treat-

ment of traumatic below-knee amputations and Gustilo and Anderson type IIIC open tibial fractures: The results of a case series. J Bone Joint Surg Br 2010;92:1563-7.
24. Bosse MJ, MacKenzie EJ, Kellam JF, Burgess AR, Webb LX, Swiontkowski MF, et al. A prospective evaluation of the clinical utility of the lower-extremity injury-severity scores. J Bone Joint Surg Am 2001;83:3-14.
25. Ly TV, Travison TG, Castillo RC, Bosse MJ, MacKenzie EJ, LEAP Study Group. Ability of lower-extremity injury severity scores to predict functional outcome after limb salvage. J Bone Joint Surg Am 2008;90:1738-43.
26. Bosse MJ, McCarthy ML, Jones AL, Webb LX, Sims SH, Sanders RW, et al. The insensate foot following severe lower extremity trauma: an indication for amputation? J Bone Joint Surg Am 2005;87:2601-8.
27. Glass GE, Pearse MF, Nanchahal J. Improving lower limb salvage following fractures with vascular injury: a systematic review and new management algorithm. J Plast Reconstr Aesthet Surg 2009;62:571-9.
28. Howard PW, Makin GS. Lower limb fractures with associated vascular injury. J Bone Joint Surg Br 1990;72:116-20.
29. Seligson D, Ostermann PA, Henry SL, Wolley T. The management of open fractures associated with arterial injury requiring vascular repair. J Trauma 1994;37:938-40.
30. O'Toole RV, Castillo RC, Pollak AN, MacKenzie EJ, Bosse MJ; LEAP Study Group. Determinants of patient satisfaction after severe lower-extremity injuries. J Bone Joint Surg Am 2008;90:1206-11.
31. Harris AM, Althausen PL, Kellam J, Bosse MJ, Castillo R; Lower Extremity Assessment Project (LEAP) Study Group. Complications following limb-threatening lower extremity trauma. J Orthop Trauma 2009;23:1-6.
32. Lange RH, Bach AW, Hansen ST Jr, Johansen KH. Open tibial fractures with associated vascular injuries: prognosis for limb salvage. J Trauma 1985;25:203-8.
33. Drost TF, Rosemurgy AS, Proctor D, Kearney RE. Outcome of treatment of combined orthopedic and arterial trauma to the lower extremity. J Trauma 1989;29:1331-4.