New Surgical Technique: Dorsal Osteosynthesis Approach for Tibial Defect Reconstruction

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The new dorsal osteosynthesis (reconstruction) approach was developed to reduce the risks of plate exposure, infection, and early removal in difficult cases such as Gustilo–Anderson type IIIB or C open tibial fractures and Cierny–Mader type III and IV chronic osteomyelitis. The advantages of this method are that the reconstruction with microvascular or pedicle fibula flaps and plating can be done through healthy non-compromised posterior compartment—no separate incision for osteosynthesis or flap insertion is needed.

Material

Retrospective cohort study was performed to evaluate the functional outcome, union rate, and complications after tibia reconstruction. Eleven patients underwent dorsal osteosynthesis for tibia defect reconstruction with free or pedicle fibula flaps in the Microsurgery Centre of Latvia between 2010 and 2015. All patients had a history of open tibia fractures. Patients were divided in three groups. In the first group, three patients developed late complications after previously done bone and soft tissue reconstructions. The second group included six patients with chronic osteomyelitis after osteosynthesis with a plate, using classical anteromedial or anterolateral approaches without any reconstruction. The third group included two patients with Gustilo–Anderson type IIIB and IIIC tibia fractures treated with monolateral and Ilizarov apparatus, also without any reconstruction. Group characteristic are shown in ►**Table 1**.

Surgical Procedure

Patient is operated in the abdominal position. Posterior compartments of both legs are on top, and feet are slightly flexed.

In cases of free flap incision going from medial side through posterior compartments, gastrocnemius muscles are retracted laterally or medially. Soleus muscle has to be dissected and sharply detached from tibia. Posterior tibial artery (PTA) and tibial nerve (TN) can be observed till bifurcation. Tibialis posterior, flexor hallucis longus, and flexor digitorum longus muscles are gently detached from medial side to avoid damaging of motor nerve branches. After dividing last muscles, dorsal side of the tibia can be fully observed. Posterior tibial vessels are dissected starting from peroneal artery (PA) till medial ankle and can be used at any level for microvascular end-to-side anastomosis. Contralateral fibula flap can be harvested from dorsal side of the leg.

If pedicled fibula flap is used for reconstruction, skin incision can be done from lateral side, closer to fibula, for better exposure of PA.[1–3] Flaps can be proximally (antegrade flow) or distally (retrograde flow) based depending on defect localization.[4] Proximally based pedicle vascularized fibula graft can be used for tibial shaft defects and retrograde flap is recommended for distal tibial defects. It is not necessary to dissect PTA and TN (►**Figs. 1** and **2**).

After flap harvest, osteosynthesis is done through dorsal approach—plate is mounted from dorsal side of the tibia. Some additional cortical screws can be used to fix a single or double barrel. Some difficulties can be anticipated in inserting the upper part of plate as bifurcation of PA and PTA lies there. Gentle distraction has to be applied to pull away blood vessels and insert screws. The skin paddle has to be pushed from the posterior side to the anterior side. After the dorsal side closure, the leg is flexed in knee joint and skin paddle is fixed. Some defects can be left for secondary healing.

We recommend leaving the external fixator on till skin heals, and remove it in outpatient clinic after 4 to 8 weeks when circular cast can be safely applied.

Methods for Evaluation

Patient's functionality was observed by Lower Extremity Functional Scale (LEFS) score.[5] X-rays, sensation, range of

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Table 1 Group characteristics

	Age	Gender	Problem	Bone defect	Reconstruction
First group					
1.	26	M	Nonunion	Tibial shaft, 2 cm	Distal pedicle, 7.9 cm
2.	43	M	Nonunion	Tibial shaft, 14 cm	Proximal pedicle, 20.2 cm
3.	45	M	Osteomyelitis 3A	Tibial shaft, 14 cm	Contralateral single barrel, 18 cm
Second group					
4.	54	M	Osteomyelitis 4A	Distal tibia, 13 cm	Contralateral single barrel, 19cm
5.	54	F	Osteomyelitis 3A	Distal tibia, 3.5 cm	Distal pedicle, 8.5 cm
6.	57	M	Osteomyelitis 4A	Distal tibia, 9.3 cm	Contralateral double barrel, 12/10 cm
7.	41	M	Osteomyelitis 3A	Distal tibia, 10.7 cm	Distal pedicle, 15,4 cm
8.	54	M	Osteomyelitis 4C	Tibial shaft, 4.6 cm	Proximal pedicle, 9,6 cm
9.	40	M	Osteomyelitis 3A	Distal tibia, 4.8 cm	Distal pedicle, 10.2 cm
Third group					
10.	24	M	Gustilo–Anderson IIIB	Tibial shaft, 6.5 cm	Contralateral double barrel, 9.6/8 cm
11.	25	M	Gustilo–Anderson IIIC	Tibial shaft, 9.3 cm	Contralateral double barrel, 11.7/11.6 cm

motion, leg length, and Medical Research Council (MRC) scale were evaluated.

Results

Seven patients responded for the study. Mean follow-up time for five patients was 2 years and 8 months; for two patients, it was less than 1 year. Mean LEFS score was 56.3 points (43–69) or 70.35% (53–86.2%) from maximal ability which is 100% according to the scale. Most of the difficulties were associated with high-intensity workouts such as running or jumping. Normal daily activities such as walking and going up or down the stairs can be done without any difficulties. No one had abnormal sensations at the TN innervations zone. The MRC scale score was M5 for all patients. M5 was evaluated if patient were able to stand in the toe position against the gravity of full resistance. Limb length differences were corrected with orthopedic foot wear (►**Figs. 3** and **4**; ►**Table 2**).

Discussion

Many surgical approaches are available for tibia osteosynthesis. The main approaches for tibial reconstruction are anteromedial, anterolateral, posteromedial, and posterolateral. Every approach has its anatomical limitations, advantages, and disadvantages.[6] The anteromedial approach is the most commonly used for distal tibial shaft reconstruction. The main disadvantage is low blood supply to the skin and subcutaneous tissue which can lead to exposed hardware. The anterolateral approach is used when the medial soft tissues are compromised. The exposure is more difficult

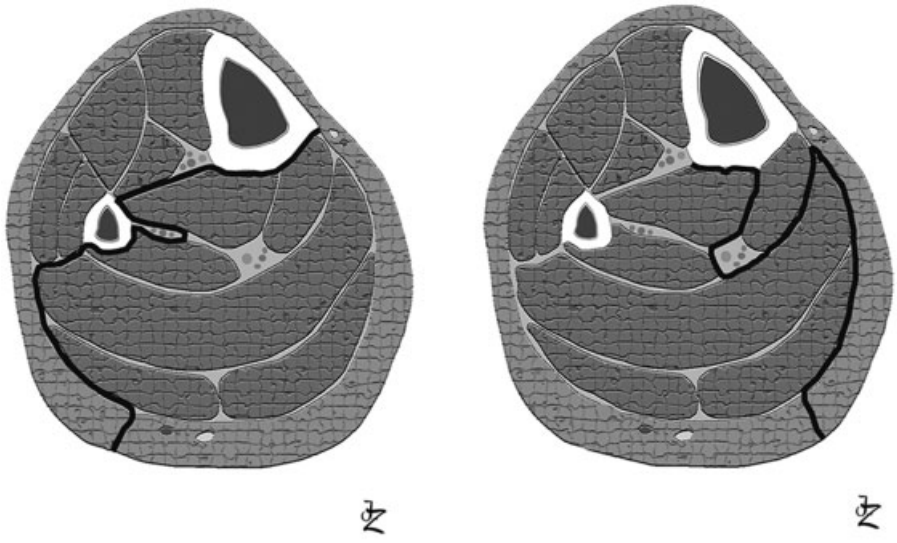

Fig. 1 The cross-section differences for the pedicle (left) and free flap (right).

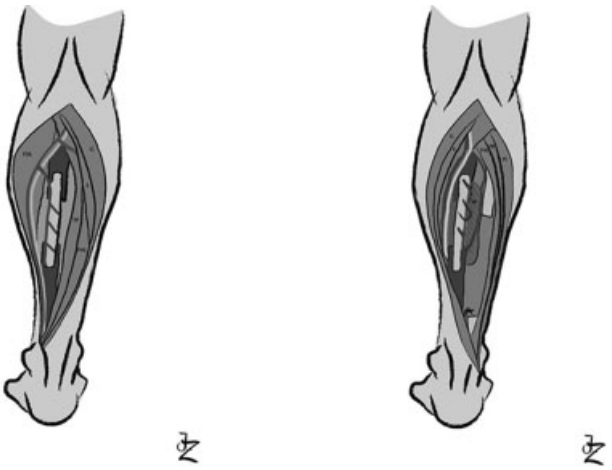

Fig. 2 The differences for flap vascular pedicles (free flap on the left and pedicle flap on the right).

because of a risk of damaging anterior tibial artery and deep peroneal nerve.[7] Classical osteosynthesis methods are developed to avoid exploration and to reduce the risk of damaging lower limb blood vessels or nerves. To reconstruct the tibia with a free or pedicle flaps, blood vessels have to be explored. Using dorsal osteosynthesis approach, a good vascular exploration for microvascular anastomosis or pedicle flaps is achieved.

The osteosynthesis hardware placed under microvascular free flap can be exposed if total or even marginal skin necrosis occurs and reoperations with new flaps might be necessary to close the defect and prevent infection. The dorsal osteosynthesis approach was developed to secure metal plates and reduce a risk of failure. Skin flap's paddle side can be healed by secondary intention without plate exposure. Of 11 patients in our study, 5 were healed by secondary intention. No plate infections were observed. Delayed postoperative complications include nonunion, recurrence or development of osteomyelitis, failure of fixation, fibular fracture, sensory disturbances, contractures, and deformities.[8,9] Graft fractures are the most common late postoperative complication. Previous authors have found the incidence of fractures between 20 and 40%.[10] One patient in our study had a broken plate with bone fracture. Patient specified that too early walking and exercises were applied on the reconstructed leg. The broken plate was removed and reosteosynthesis done.

The dorsal osteosynthesis approach is developed for the tibia reconstruction with pedicle or free bone (contralateral fibula, iliac crest). Treatment with contralateral fibula is selected for the uncomplicated patients. In these cases double-barrel fibula graft is preferred as fast recovery can be expected and patients can start physical activities after cast is removed.

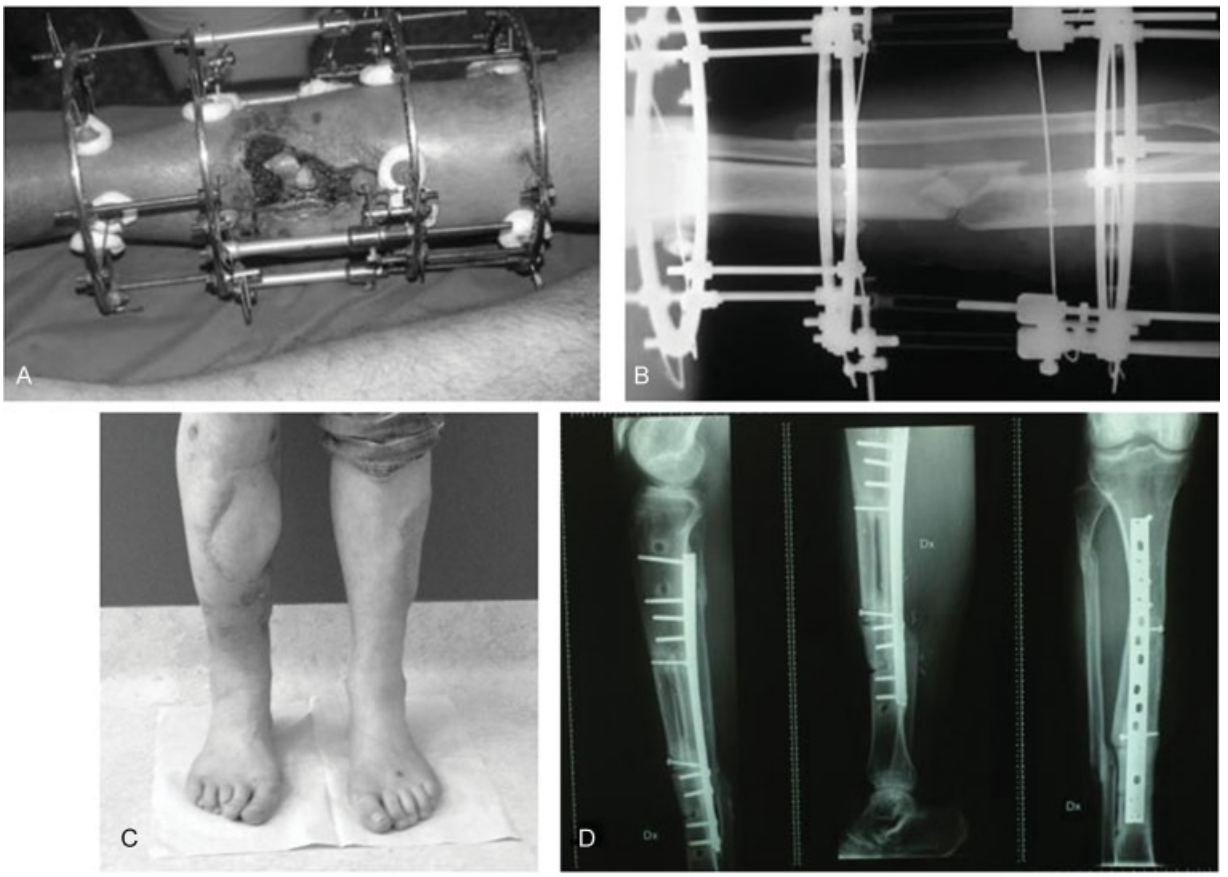

Fig. 3 A 26-year-old patient with open tibial fracture (Gustilo–Anderson type IIIB) treated with Ilizarov external fixator. (**A, B**) Infected open tibial fracture. (**C**, **D**). Follow-up 2 years after free double-barrel fibula.

Fig. 4 A 27-years-old patient with left tibial injury (Gustilo–Anderson type IIIC). Free latissimus dorsi, fibula flaps used for early reconstruction. Nonvascularized iliac crest bone used for reosteosynthesis. (**A, B**) Septic un-union. (**C, D**) Follow-up 1 year after distal pedicled fibula flap.

Pedicled fibulas are selected for complicated patients as there is higher risk for below-knee amputation. Proximally or distally based pedicle fibula flap can be selected depending on defect localization and vascularity. Fibula fractures are not contraindications for flap selection. The same region operations are preferred for the high failure risk patients as last chance operation before amputation. Salvage of the potential donor side is a huge benefit for these patients as there is not any iatrogenic damage in healthy side.

Conclusion

The dorsal osteosynthesis approach can be primary choice in cases when large soft tissue defect is expected, which increases the risk of skin paddle necrosis, or as a last reconstruction option if conventional reconstructions fail. Advantages of this method are the following: incision can be made throughout healthy noncompromised tissue; free access for anastomosis; contralateral fibula flap can be harvested from

Table 2 Study outcome data

Patient	Follow-up	LEFS score	ROM knee	ROM ankle	MRC	Limb, cm	Late complications
1	2 y 11 mo	43, 53.75%	10-0-130	15-0-50	M5	82/83	None
2	3 y 1 mo	55, 68.75%	0-0-75	20-0-40	M5	84/85	None
3	3 y 0 mo	65, 81.25%	10-0-125	15-0-40	M5	89/92	Broken plate
4	2 y 9 mo	44, 55%	5-0-115	15-0-50	M5	105/–	None
5	8 mo	63, 78.75%	0-0-120	15-0-45	M5	95/96	None
6	10 mo	69, 86.2%	5-0-120	10-0-30	M5	100/105	None
7	8 mo	55, 68.75%	0-0-90	10-0-30	M5	84/85	None

Abbreviations: LEFS, Lower Extremity Functional Scale; MRC, Medical Research Council scale; ROM, range of motion.

dorsal side; pedicle vascularized fibula flap can be harvested through the same incision; operation time does not increase; and in cases of partial tissue necrosis it can be left for secondary healing.

In spite of small number of patients in our study, we need to continue our work to evaluate the effectiveness of this approach with other methods.

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