Fibula-pro-tibia transfer with external fixator after tibia fracture with extensive bone defect: a case report

Verdoni F[1], Compagnone D[2], Grasso F[2], Peretti GM[1,3], Mangiavini L[1,3]

[1]IRCCS Istituto Ortopedico Galeazzi, Milan, Italy

[2]Residency Program in Orthopaedics and Traumatology, University of Milan, Milan, Italy
[3]Department of Biomedical Sciences for Health, University of Milan, Italy

Key words: fracture, bone defect, external fixator, case report

#Corresponding author

Laura Mangiavini

IRCCS Istituto Ortopedico Galeazzi

Via R. Galeazzi 4, 20161, Milan, Italy

Tel.: +39 02 6621 4930

Email: laura.mangiavini@unimi.it

Abstract

A 27-year-old girl suffered a tibial fracture with an extensive bone defect due to a major trauma. At first, she was treated with a plate with the purpose to obtain a fibula-pro-tibia transfer, without any improvement. At one-year-follow up, a non-union due to mechanical hardware failure was shown by x-ray. Thus, a second surgery was performed: the ipsilateral fibula was tightly wedged between the preserved proximal and distal third of tibia with an external fixator. We report a follow up of 1 year after the reconstruction, that allowed a good bone healing and a remodeling with also further ossification of the periosteal sheath of the fibula.

Case Report

In June 2009 a 27-year-old girl fell from a window and suffered an open fracture of her right tibia with an extensive bone loss (Gustilo type III) (1). She was treated first at another institute with internal fixation using the "fibula-pro-tibia" procedure (fusing the tibia and fibula together to create a one-bone leg). The proximal and distal part of the tibia were plated, and the screws were brought across to the fibula cortex (**Figure 1A**).

At the 3- and 6-months follow-ups, X-Rays showed no evidence of bone healing and the patient's clinical conditions didn't improve. At the clinical inspection walking was not conceivable and pain did not permit joint mobilization, neither knee nor ankle. Besides, remodeling of the reconstructed tibia was not present at the radiological examination (**Figure 1A**).

At 9 months follow-up the proximal screws appeared broken; however, no further treatments were applied (**Figure 1B**).

The patient first presented to us in June 2010. She reported worsening in pain and a leg deformity was evident. X-rays showed hardware failure at the level of the distal fibula-tibia junction, due to non-union, and the consequent valgus deformity of the ankle (**Figure 2**).

A surgical procedure became necessary: the skin and the soft tissues were compromised and the development of an atrophic non-union limited the therapeutic strategies. Moreover, a severe external popliteal sciatic nerve paresis and limitation of the right ankle range of motion worsened the clinical conditions.

In July 2010 we opted for stabilization with an external fixator: the ipsilateral fibula was tightly wedged between the preserved proximal and distal third of tibia, as a local bone flap. Tibia was fixed to the fibula cortex with pins, to ensure stability and to restore the physiological load axis (**Figure 3A, B**).

The patient was discharged from the hospital after 5 days from the surgery, walking on crutches. A rehabilitation program was suggested, to increase muscle strength and to improve the neurological status.

At 1-year follow-up no evidence of bone healing was shown at X-rays (**Figure 3C**); thus, the patient underwent another surgery five months later. We decided to increase the compaction thrust by using two olive wires: the first one was placed with an oblique

direction, pushing the middle section of the fibula, to achieve medial translation of the fibula; the second one was placed with opposite direction, pushing the distal part of the tibia towards fibula, so as to obtain major stability of the frame and to decrease the distance between tibia and fibula (**Figure 3D**).

In June 2011 radiological evidence of initial medial shift of the fibula towards the distal part of the tibia and early callus formation were found. A further surgery was necessary to ensure a complete medial translation: we replaced the former proximal oblique olive wire with a right direction one in order to enhance the medial shift (**Figure 3E, F**).

In December 2011 X-rays showed a 12° valgus deformity of the distal part of the tibia (**Figure 4A**) due to patient overweight and relative instability of the external fixation frame. Bone healing process requires two conditions: the stability on the bony segment and their compression with a corrected axis load; therefore, we planned another surgery in January 2012 using an olive wire pushing the distal part of the tibia, to obtain a reduction of the valgus displacement (**Figure 4B**).

Six months after surgery, the compression force seemed inadequate, confirmed by radiological evidence of tibia and fibula diastasis. We opted for the use of a 3.5 mm cannulated screw to obtain better bone regeneration and compression, with the aim to reduce the dislocation, as shown in (**Figure 4C**).

At the following annual controls, encouraging bone healing signs with progressive fibula hypertrophy and improvement of the bone regeneration were assessed, especially in the proximal portion of the tibia, where formation of an exuberant callus was evident (**Figure 4D**). In June 2015 bone regeneration was complete, and the fibula was totally integrated with the tibia.

In conclusion, after a 7 years treatment we obtained satisfying results in terms of stability of the “new tibia” and we removed the external fixator in January 2017, recommending a cast for the following two months, subsequently replaced by an orthosis Walker type that allowed complete load and the possibility to walk with a protected leg (**Figure 4E**).

Results

At one-year follow-up, a physical and psychological recovery was achieved. Patient was able to walk without crutches with a less than 2 cm right lower limb hypometria, which was well compensated during the ambulation. Radiologically no evidence of valgus or varus deformity was present; however, a residual procurvatum of the tibia was shown in the lateral view. An ankle arthrodesis was clinically assessed in association with deficit of the anterior tibialis, already present before our surgery. A complete knee ROM was otherwise found. During the 7 years treatment, no major complications had been reported, except for superficial pin site infections.

Discussion

Tibial open fractures often result in a bone gap. In these cases, surgical repair may be difficult and unsuccessful, due to the entity of the defect, the soft tissue involvement and the vascular conditions, which may cause osteomyelitis.

Conventional bone grafting leads to optimal bone healing and satisfactory clinical result for defects shorter than 6 cm, if the area is well vascularized and not infected (2). In the case of major bone gaps, conventional techniques of bone grafting may increase the risk of non-union and infection; thus, advanced surgical procedures should be considered.

Flanagan JJ. et al. (1947) (3) proposed a hemidiaphisectomy of the affected bone; in this case, the removed cortex was used as a graft. During the years, some alternative limb-salvage techniques have been proposed by several authors. The surgical options that have shown the best clinical results are controlateral fibular grafting (4), the bone transport using the Ilizarov method (5), the Masquelet's Technique (6) and ipsilateral fibula-pro-tibia.

Ipsilateral fibular grafting was first proposed by Hanh in 1884. The surgical procedure was developed by Huntington (7) in 1905, who described the use of the whole segment of fibula to bridge a tibial defect with an internal fixation. Some authors modified the technique during the XX century, readapting it to the specific clinical cases (8-11).

In 1998 Catagni et al. (12) first, followed by Kim et al. (13), introduced ipsilateral fibular transfer with an external fixator using the traction by olive wires to accomplish gradual transport.

Although the potential advantages of this surgical procedure could be interesting, there are just few cases published in literature (12, 14, 15), probably due to the low incidence of the extreme clinical condition and the technical difficulties of the surgical technique.

The case we described had some additional issue: the peripheral neurological and the soft tissues conditions were seriously compromised; a previous treatment had been unsuccessful; moreover, a septic status limited the therapeutic possibilities.

For all these reasons, the use of controlateral vascularized fibula was not preferable, to avoid possible complications to the unaffected limb. Besides the impaired vascularization of the receiving site would have possibly compromised the graft vitality.

The external fixator maintains the limb stability while achieving the transport of the ipsilateral fibula, which allows for early weight-bearing to increase fracture healing potential (16). The early load also leads to hypertrophy of the bone which is desirable in the fibula-pro-tibia transfer.

Amputation was maybe the only option and the simplest surgical solution to treat this patient, who appeared exhausted due to the failure of previous treatments. Despite the recent advances in leg prosthesis techniques (17), limb amputation is still considered disabling in our society and it is associated with anxiety related disorders and depression (18). Besides the cosmetic aspect needed to be considered in a 27 years-old lady. The cost difference between amputation and reconstruction has not been well assessed in literature; some studies underline the surgical and medical expenses and the cost of rehabilitation after the surgical salvage procedures are higher than those for the

amputation (13, 19). Williams, considering the need of prosthetic changes with years, reputed the long-term costs of amputation greater than for the external fixator treatment, once limb salvage has been accomplished (20).

Conclusion

Amputation was the only therapeutic option in the past for open fractures with massive bone defects. Nowadays limb salvage surgery should be considered in these extreme situations as it could be a reasonable alternative. We think the fibula-pro-tibia transfer with the Ilizarov method may lead to a satisfying bone healing and compensatory hypertrophy of the fibula to create a one-bone leg. In our case, the 7 years treatment with the external fixator and the residual ankle arthrodesis represent the negative aspects of the procedure, but the patient well accepted these side-effects as this surgical technique allowed her for maintaining the lower limb and for walking without pain. To date, the only limits of this surgical approach are the technical difficulties and the need of an experienced surgeon in the Ilizarov method.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Gustilo RB, Gruninger RP and Davis T. Classification of type III (severe) open fractures relative to treatment and results. Orthopedics 1987; 10(12): 1781-1788.
2. Green SA and Dlabal TA. The open bone graft for septic nonunion. Clin Orthop Relat Res 1983; (180): 117-124.
3. Flanagan JJ and Burem HS. Reconstruction of defects of the tibia and femur with apposing massive grafts from the affected bone. J Bone Joint Surg Am 1947; 29(3): 587-597.
4. Kovoor CC, Jayakumar R, George V, Padmanabhan V, Guild A and Viswanath S. Vascularized fibular graft in infected tibial bone loss. Indian J Orthop 2011; 45(4): 330-335.
5. Zhang Y, Wang Y, Di J and Peng A. Double-level bone transport for large post-traumatic tibial bone defects: a single centre experience of sixteen cases. Int Orthop 2018; 42(5): 1157-1164.
6. Sivakumar R, Mohideen MG, Chidambaram M, Vinoth T, Singhi PK and Somashekar V. Management of Large Bone Defects in Diaphyseal Fractures by Induced Membrane Formation by Masquelet's Technique. J Orthop Case Rep 2016; 6(3): 59-62.
7. Huntington TW. VI. Case of Bone Transference: Use of a Segment of Fibula to Supply a Defect in the Tibia. Ann Surg 1905; 41(2): 249-251.
8. Duparc J and Valette C. [Peroneo-tibial osteosynthesis in the treatment of infected leg fractures]. Rev Chir Orthop Reparatrice Appar Mot 1968; 54(2): 153-160.
9. Milch H. Tibiofibular synostosis for non-union of the tibia. Surgery 1950; 27(5): 770-779.
10. Stulz E and Folschveiller J. [Upper and lower tibiofibular consolidation in the treatment of severely infected pseudarthrosis of the tibia]. Rev Chir Orthop Reparatrice Appar Mot 1961; 47: 609-612.
11. Zanoli R and Guerzoni PL. [Osteosynthesis of the Fibula as an Adjuvant Stage in Fibula Pro Tibia]. Chir Organi Mov 1963; 52: 173-179.
12. Catagni MA, Camagni M, Combi A and Ottaviani G. Medial fibula transport with the Ilizarov frame to treat massive tibial bone loss. Clin Orthop Relat Res 2006; 448: 208-216.
13. Kim HS, Jahng JS, Han DY, Park HW and Chun CH. Immediate ipsilateral fibular transfer in a large tibial defect using a ring fixator. A case report. Int Orthop 1998; 22(5): 321-324.
14. Fohn M, Bannasch H and Stark GB. Single step fibula-pro-tibia transfer and soft tissue coverage with free myocutaneous latissimus dorsi flap after extensive osteomyelitis and soft tissue necrosis--a 3 year follow up. J Plast Reconstr Aesthet Surg 2009; 62(11): e466-470.
15. Paley D, Catagni MA, Argnani F, Villa A, Benedetti GB and Cattaneo R. Ilizarov treatment of tibial nonunions with bone loss. Clin Orthop Relat Res 1989; (241): 146-165.
16. Kubiak EN, Beebe MJ, North K, Hitchcock R and Potter MQ. Early weight bearing after lower extremity fractures in adults. J Am Acad Orthop Surg 2013; 21(12): 727-738.

17. Dietrich C, Nehrdich S, Seifert S, Blume KR, Miltner WHR, Hofmann GO and Weiss T. Leg Prosthesis With Somatosensory Feedback Reduces Phantom Limb Pain and Increases Functionality. Front Neurol 2018; 9: 270.
18. Tennent DJ, Polfer EM, Sgromolo NM, Krueger CA and Potter BK. Characterization of disability following traumatic through knee and transfemoral amputations. Injury 2018.
19. Bondurant FJ, Cotler HB, Buckle R, Miller-Crotchett P and Browner BD. The medical and economic impact of severely injured lower extremities. J Trauma 1988; 28(8): 1270-1273.
20. Williams MO. Long-term cost comparison of major limb salvage using the Ilizarov method versus amputation. Clin Orthop Relat Res 1994; (301): 156-158.

Figure Legends

Figure 1

The proximal and distal part of the tibia were plated (A); proximal screws appeared broken at 9- month follow-up.

Figure 2

X-rays showed hardware failure at the level of the distal fibula-tibia junction, due to non-union, and the consequent valgus deformity of the ankle.

Figure 3

A,B. Stabilization of bone graft by external fixator frame.

C,D. No evidence of bone healing at 1-year follow-up (C); olive wires were used to increase the compaction (D).

E,F. Early callus formation (E); change of olive wire direction (F).

Figure 4

A. The x-rays show a valgus deformity of the distal part of the tibia.

B. Reduction of the valgus displacement after the revision surgery with an olive wire pushing the distal part of the tibia.

C. A 3,5 mm cannulated screw was used with the aim to reduce the dislocation.

D. The last x-ray follow-up with the external fixator showing encouraging bone healing.

E. The x-ray control after the removal of external fixator; a satisfying result in terms of stability of the "new tibia" is evident and a complete load was allowed.