Retrospective Evaluation Study

DOCKING POINT NON-UNION TREATED WITH INTRAMEDULLARY NAILING: A RETROSPECTIVE STUDY

G. Martin[1], G. Conza[1], N. Garofalo[1], N. Di Cristofaro[1], M. Macera[2], G. Iodice[1], G. Toro[3], A. Braile[4,5] and G. Toro[1]

[1]Department of Medical and Surgical Specialties and Dentistry, University of Campania "Luigi Vanvitelli", Napoli, Italy;
[2]Unit of Infectious Disease, AOU Vanvitelli, Napoli, Italy;
[3]Unit of Radiology, San Paolo Hospital, Napoli, Italy;
[4]Unit of Orthopaedics and Traumatology, Ospedale Del Mare, Napoli, Italy;
[5]Department of Clinical Sciences and Translational Medicine, Tor Vergata University, Rome, Italy

Correspondence to:
Giuseppe Toro, PhD, MD
Department of Medical and Surgical Specialties and Dentistry,
University of Campania "Luigi Vanvitelli",
Via L. De Crecchio, 4,
Naples, Italy
e-mail: giuseppe.toro@unicampania.it

ABSTRACT

Fracture septic nonunion is one of the most demanding complications for both the orthopedic surgeon and the patient, considering the need for several procedures that significantly impact patients' quality of life. Very often, fracture septic nonunion is associated with bone loss. External fixation through the Ilizarov principles promotes the filling of the bone gap thanks to distraction osteogenesis, a technique also known as bone transport. However, fibrous tissue frequently appears during the bone transport at the lower end, leading to a docking point nonunion. This study aimed to evaluate the outcomes of patients presenting with docking point nonunion treated using intramedullary nailing. We conducted a retrospective study on those patients treated with bone transport who developed docking point nonunion and treated with intramedullary nailing. For each patient, we collected demographic data, prior diagnosis, time to heal the initial injury, ASA score, and other recalcitrant lower limb discrepancies and malalignments. Specific questionnaires, including the Oxford Knee Score, Oxford Hip Score, AOFAS Foot Score, and ASAMI Scoring System, were used to evaluate the functionality of the affected limbs. This study included 8 patients (6 males and 2 females), aged between 23 and 65 years. Seven patients had a diagnosis of a tibial nonunion, and one had a femoral nonunion. Radiographically, all patients had a gap with an average length of 5.03 cm (range 2.14-10.1 cm). At the final follow-up, all patients showed difficulty walking on uneven surfaces but not on flat surfaces. All patients had limb length discrepancies, with an average of 1.5 cm (range from 0.5 to 3.5 cm). Five out of 8 patients presented with a slight malalignment: 3 in valgus and 2 in varus, with an average deviation of 5.8° (range 5-11°). The use of the Ilizarov bone transport, followed by intramedullary nailing, is effective in recovering bone loss and achieving complete healing of the docking point in a relatively short time. This approach is associated with a low incidence of post-traumatic deformities and preservation of limb functionality within a relatively short period.

KEYWORDS: *fracture, septic, bone loss, tibia, non-union, Oxford Knee Score, Oxford Hip Score*

Received: 13 September 2022
Accepted: 20 October 2022

INTRODUCTION

Non-union defines a fracture that is not healed after 6-to-9 months and/or the absence of callus progression on sequential X-rays (1, 2). Septic nonunion is a condition that considerably affects the patient's quality of life, as it results in chronic pain and functional impairment (1, 3). The treatment is often difficult for both the patient and the orthopedic surgeon. Nowadays, various therapeutic strategies are available to address nonunion, ranging from conservative methods, including immobilization and bone stimulation, to pharmacological interventions with osteoinductive agents and extending to more advanced surgical options (1, 4-7). However, the key pillars in the management of septic nonunion consist of the surgical debridement of the fracture site, mechanical stabilization of the bone segment, and subsequent reconstruction using bone grafts or biomaterials aimed to restore the structural and functional integrity of the affected bone (1, 8). Among the many surgical techniques available, the Ilizarov method is particularly noteworthy (9). It is based on applying a circular external fixator that stabilizes the affected bone and encourages healing and tissue regeneration, exploiting the distraction osteogenesis observed in bone transport.

However, bone transport may take time, and one of the most prevalent complications encountered during this treatment is the nonunion of the docking point (3). This complication seems to be linked to the development of fibrous tissue over time between the osteotomy and the arrival of the transported bone segment at the endpoint of the transport. Currently, most authors recommend periodic evaluations of the docking point during bone transport and its debridement to remove fibrous tissue (3). The aim of this study is to evaluate the effectiveness of intramedullary nailing in treating docking point nonunion.

MATERIALS AND METHODS

We conducted a retrospective study on those patients with a septic non-union, treated with the bone transport technique complicated with a docking point nonunion treated with an intramedullary nail from 2010 to 2020. Each patient was evaluated through a comprehensive medical history and a detailed physical examination. The following data were collected: personal information, previous diagnosis, ASA score, healing time of the initial lesion, and any residual lower limb discrepancies and malalignment.

The primary endpoints were healing rate and time to healing (defined as the time elapsed between the surgery and the achievement of healing). Bone healing was defined as the union of at least three cortices. The secondary endpoints were related to limb function, evaluated using the Oxford Knee Score, American Orthopaedic Foot & Ankle Society (AOFAS) Foot Score, Oxford Hip Score, and the Association for the Study and Application of the Method of Ilizarov International and External Fixation (ASAMI) Scoring System.

RESULTS

Eight patients met the inclusion criteria, 6 males and 2 females, aged between 23 and 65. Seven of 8 patients had a tibial nonunion, while the other had a femoral nonunion. The previous fractures were all open, except in one case (Patient No. 2, Male, 48 years old). The affected limb was the left in 50% of the cases and the right in the remaining 50%; in all cases, the bone transport method was used, with an external fixator followed by an intramedullary nail. The mean bone gap before the start of the treatment was 5.03 cm (range 2.14 - 10) (Table I).

Table I. *Characteristics of the cohort and results of the proposed treatment.*

Id	Age	Sex	Asa	Non-union site		Open fracture (y/n)	Bone gap (cm)	Fracture healing (y/n)	Healing time (months)	OKS	AOFAS	OHS	Residual lower limb discrepancy (cm)	Residual malalignment	Residual deformity (degrees)
1	33	M	2	femur	distal third	Y	2.89	Y	11	24	NA	44	3	varus	10
2	48	M	1	tibia	distal third	N	3.72	Y	9	55	86	NA	1	varus	10.44

3	59	M	3	tibia	proxi-mal third	Y	7.47	Y	8	45	65	NA	0.5	valgus	5.19
4	62	M	2	tibia	distal third	Y	10.10	Y	8	6	10	NA	1,5	No	--
5	23	M	1	tibia	distal third	Y	2.63	Y	12	25	67	NA	0,5	No	--
6	65	M	3	tibia	distal third	Y	6.63	Y	7	25	49	NA	3,5	valgus	11
7	29	F	4	tibia	middl e third	Y	4.94	Y	5	24	61	NA	2	No	--
8	52	M	1	tibia	distal third	Y	2.15	Y	3	46	100	NA	0,5	valgus	10.38

NA: not available.

In all patients, complete healing was achieved after an average of 7 months. The shortest healing time reported was 3 months (Patient No. 7, Female, 29 years old). Regarding the secondary endpoints, the average Oxford Knee Score was 31 points, ranging from 6 to 55. The AOFAS Foot Scale averaged 62 points, ranging from 10 to 100. Regarding the patient who underwent femoral reconstruction, the Oxford Hip Score was 44 (Table I). Finally, the clinical and radiographic results according to the ASAMI Scoring System for the bone part were: excellent in 4 cases (50%), good in 2 (25%), fair in 0 (0%), and poor in 2 (25%) (Table II), while in the functional part of the ASAMI Scoring System, the results were: excellent in 2 cases (25%), good in 4 (50%), and fair in 2 (25%) (Table III).

Table II. *Results according to the ASAMI Scoring System – bone part.*

	Description	Patients
Excellent	Consolidation, absence of infection, deformity < 7°, lower limb length discrepancy <2.5 cm	4 (50%)
Good	Consolidation + two criteria among: absence of infection, deformity <7°, lower limb length discrepancy <2.5 cm	2 (25%)
Fair	Consolidation + one criterion among: absence of infection, deformity <7°, lower limb length discrepancy <2.5 cm	0
Poor	Lack of consolidation or refracture or consolidation + deformity >7° + lower limb length discrepancy >2.5 cm	2 (25%)

Table III. *Results according to the ASAMI Scoring System – functional part.*

	Description	Patients
Excellent	Active, no limping, minimal stiffness (extension deficit <15°, ankle dorsiflexion deficit <15°)	2 (25%)
Good	Active + one or two criteria among: limping, stiffness, hyporeflexia, pain	4 (50%)
Fair	Active + three or four criteria among: limping, stiffness, hyporeflexia, pain	2 (25%)
Poor	Inactive (difficulty performing normal daily activities)	0
Failure	Amputation	0

All patients showed a slight limb length discrepancy, with an average of 1.5 cm, ranging from 0.5 to 3.5 cm. Five patients presented a residual malalignment. Among these, the distribution is as follows: 3 patients with valgus, 2 with varus, and 3 with no deviation, with an average angle of 5.8 degrees, ranging from 5 to 11 degrees.

DISCUSSION

The results from this observational study suggest that the use of the intramedullary nail after bone transport and external fixation may represent a reliable treatment for fracture non-union complicated at the docking point. This study described a clear decision process for selecting the patients who followed a systematic protocol represented by the application of Ilizarov principles using a circular fixator for bone transport and subsequent nailing at the docking point. It has been shown that different fixator constructs can influence the outcome of the Ilizarov method (10, 11).

Our selection method allowed us to reduce variability among the patients by using the same type of fixator (Ilizarov circular frame), the same diagnostic criteria, and the same functional evaluation using appropriate scores. The patients were consistently monitored throughout the process to evaluate the functional recovery of the affected limb and the associated sequelae, as well as to assess the impact of these on each patient's quality of life (Fig. 1).

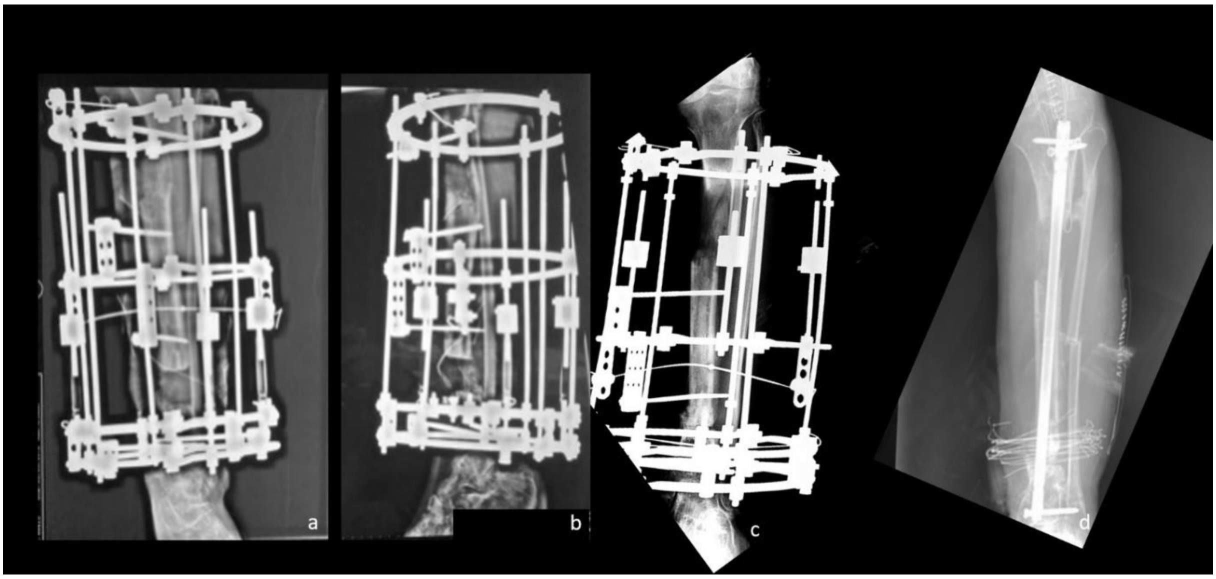

Fig. 1. *A clinical case showing the proposed treatment. In **a**) and **b**) anteroposterior and lateral X-rays during bone transport; **c**): docking point nonunion; **d**): intramedullary nailing of the docking point non-union.*

The use of the intramedullary nail was a breakthrough in the treatment of the docking point non-union (11), as also confirmed by our observations from both a radiographical and functional perspective. The average healing time (7 months) was relatively fast compared to other studies in the literature (11-13). For example, in the study by Sigmund et al. (9), the average healing time was longer (10 months), while it was 12 months in another study conducted by Lavini et al. (13).

For the functional assessment, as previously described, we used a series of scores specifically conceived for the function of the knee, ankle, and hip. Overall, the functional results were satisfactory in most cases. The sequelae analyzed in the follow-ups include limb length discrepancies and malalignments, which, from a broader perspective of the results described in the literature, represent minor complications. Indeed, considering various studies on the subject, many present much more troublesome complications, including recurrences of the infection (if any) that required unplanned reoperations, accompanied by recurrent infections during follow-up (12), as well as non-unions and failures at the docking site (13). Finally, but no less importantly, there have been cases of failure due to non-union of the regeneration (14-16).

On the other hand, in this study, we did not encounter these complications, partly due to the small sample size, the techniques we used (external fixator and subsequent intramedullary nail), and the multidisciplinary approach based on the contemporary evaluation of the orthopedic surgeon, the infectious disease specialist, and the radiologist. Nevertheless, as previously mentioned, complications still exist. Limb length discrepancies were observed in all patients during the follow-ups, with a minimum of 0.5 cm and a maximum of 3.5 cm, while malalignments were not found in all patients. Only three patients presented with valgus malalignment, two patients had varus malalignment, and the remaining three had no malalignment. We addressed these issues with elevated footwear, which proved to be effective in correcting all the detected discrepancies, though two patients also required the use of a cane.

Regarding functionality, we found that 75% of patients had an excellent/good score on the ASAMI Scoring System, while 25% had a fair score. No patient had a poor score or required amputation. This indicates that all patients remained active. Additionally, 25% of patients reported no limp, pain, or stiffness; 50% experienced stiffness but no limp or pain; and only two patients, representing 25%, had limp, pain, and stiffness. Overall, we can conclude that in most patients, the function of the affected limb remained mostly preserved, and the aforementioned sequelae did not significantly affect their activities. Our study has some limitations, primarily due to the small sample size and the absence of a control group. However, we felt it necessary to apply strict inclusion and exclusion criteria to obtain a more homogeneous group, especially considering that the pathology studied is rarely observed. Moreover, the occurrence of docking point nun-union in the case of septic non-union is a dreadful but uncommon complication and there is no gold standard for its treatment

CONCLUSIONS

The bone transport method with external fixation, followed by the intramedullary nail, is effective in recovering bone loss and achieving complete healing at the docking point in a short period while maintaining the infection control of the affected bone. Furthermore, this combined approach is associated with mild post-traumatic deformities that seem to be correlated to limb function and patient satisfaction. Finally, the results confirm that the use of the intramedullary nail leads to very satisfactory outcomes in a relatively short time, a condition that, in our opinion, ameliorates patients' compliance and satisfaction with the treatment.

REFERENCES

1. Lowenberg DW, Buntic RF, Buncke GM, Parrett BM. Long-Term Results and Costs of Muscle Flap Coverage With Ilizarov Bone Transport in Lower Limb Salvage. *Journal of Orthopaedic Trauma*. 2013;27(10):576-581. doi:https://doi.org/10.1097/bot.0b013e31828afde4
2. Hak DJ, Fitzpatrick D, Bishop JA, et al. Delayed union and nonunions: Epidemiology, clinical issues, and financial aspects. *Injury*. 2014;45:S3-S7. doi:https://doi.org/10.1016/j.injury.2014.04.002
3. Giotakis N, Narayan B, Nayagam S. Distraction osteogenesis and nonunion of the docking site: Is there an ideal treatment option? *Injury*. 2007;38(1):S100-S107. doi:https://doi.org/10.1016/j.injury.2007.02.015
4. Toro G, Lepore F, Calabrò G, et al. Humeral shaft non-union in the elderly: Results with cortical graft plus stem cells. *Injury*. 2019;50:S75-S79. doi:https://doi.org/10.1016/j.injury.2019.01.050
5. Coppola C, Del Buono A, Maffulli N. Teriparatide in Fracture Non-Unions. *Translational medicine at UniSA.* 2015;12:47-53.
6. Toro G, Moretti A, Toro G, et al. Surgical treatment of neglected hip fracture in children with cerebral palsy: case report and review of the literature. *Clinical Cases in Mineral and Bone Metabolism*. 2017;14(3):317. doi:https://doi.org/10.11138/ccmbm/2017.14.3.317
7. Toro G, Moretti A, Paoletta M, De Cicco A, Braile A, Panni AS. Neglected femoral neck fractures in cerebral palsy: a narrative review. *EFORT Open Reviews*. 2020;5(1):58-64. doi:https://doi.org/10.1302/2058-5241.5.190019
8. Metsemakers WJ, Kuehl R, Moriarty TF, et al. Infection after fracture fixation: Current surgical and microbiological concepts. *Injury*. 2018;49(3):511-522. doi:https://doi.org/10.1016/j.injury.2016.09.019
9. Sigmund IK, Ferguson J, Govaert GAM, Stubbs D, McNally MA. Comparison of Ilizarov Bifocal, Acute Shortening and Relengthening with Bone Transport in the Treatment of Infected, Segmental Defects of the Tibia. *Journal of Clinical Medicine*. 2020;9(2):279. doi:https://doi.org/10.3390/jcm9020279
10. Zhang Z, Benton Swanson W, Wang YH, Lin W, Wang G. Infection-free rates and Sequelae predict factors in bone transportation for infected tibia: a systematic review and meta-analysis. *BMC Musculoskelet Disord*. 2018;19(1). doi:https://doi.org/10.1186/s12891-018-2363-5
11. Gülabi D, Erdem M, Çeçen GS, Avcı C, Sağlam N, Fevzi Sağlam. Ilizarov Fixator Combined With an Intramedullary Nail for Tibial Nonunions With Bone Loss: Is It Effective? *Clinical Orthopaedics and Related Research*. 2014;472(12):3892-3901. doi:https://doi.org/10.1007/s11999-014-3640-8
12. Kinik H, Kalem M. Ilizarov segmental bone transport of infected tibial nonunions requiring extensive debridement with an average distraction length of 9,5 centimetres. Is it safe? *Injury*. 2021;52(8):2425-2433. doi:https://doi.org/10.1016/j.injury.2019.12.025
13. Lavini F, Dall'Oca C, Bartolozzi P. Bone transport and compression-distraction in the treatment of bone loss of the lower limbs. *Injury*. 2010;41(11):1191-1195. doi:https://doi.org/10.1016/j.injury.2010.09.030
14. Lovisetti G, Sala F. Clinical strategies at the docking site of distraction osteogenesis: Are open procedures superior to the simple compression of Ilizarov? *Injury*. 2013;44:S58-S62. doi:https://doi.org/10.1016/s0020-1383(13)70014-7

15. Tetsworth K, Paley D, Sen C, et al. Bone transport versus acute shortening for the management of infected tibial non-unions with bone defects. *Injury*. 2017;48(10):2276-2284. doi:https://doi.org/10.1016/j.injury.2017.07.018
16. Paley D. Problems, Obstacles, and Complications of Limb Lengthening by the Ilizarov Technique. *Clinical Orthopaedics and Related Research*. 1990;&NA;(250):81???104. doi:https://doi.org/10.1097/00003086-199001000-00011