Trauma Case Reports 42 (2022) 100718

Contents lists available at ScienceDirect

Trauma Case Reports

journal homepage: www.elsevier.com/locate/tcr

Treatment of a tibial bone defect with a motorized intramedullary bone transport nail: A case review with 32 months follow up

Jorge Carrión Martínez *, Miguel A. Cámara Baeza, Alberto Durán Morell, Pedro Calafell Mas, Ana B. González Gil

Department of trauma surgery, University Hospital Son Espases, Spain

A R T I C L E I N F O

Keywords:
Bone transport
Intramedullary nail
Segmental defects
Non-union

A B S T R A C T

Nowadays, massive segmental bone defects represent a surgical challenge for trauma surgeons. Most of these injuries appear in the context of high-energy trauma, not only significantly affecting the bones, but also involving severe injuries of the adjacent soft tissues. For these reasons, their treatment requires complex reconstruction surgeries.

There are multiple techniques to treat bone defects, bone transport being one of the most widely used. Historically, external fixators (monolateral and circular) have been and still are the gold standard for performing this technique, although they are not exempt from complications. By means of specific intramedullary nails for bone transport, it is possible to minimize the complications of external fixation, allowing large tibial bone defects to be treated through distraction osteogenesis (all-internal system), which is favoured by early weight bearing.

Presentation of the case

A 51-year-old male was referred to our centre for evaluation and treatment of a bone defect in the right tibia, which was a sequela of an old grade IIIA Gustilo-Anderson fracture.

In 1994, he had suffered a car accident. He had been referred to his reference hospital with a polytrauma code. In addition to the open fracture in the right tibia, he presented closed fractures in the left femur, tibia and fibula, which had been treated surgically and had evolved satisfactorily.

Regarding the right tibia, after initial management in two stages (external fixation and subsequent osteosynthesis), the patient presented multiple complications, which can be summarized as follows: septic pseudoarthrosis with osteosynthesis failure, chronic osteomyelitis, and soft tissue defect. Our patient had underwent more than 30 surgical interventions in different centres, including the necessary covering of the lesion with a sural flap by the plastic surgery service.

Preoperative assessment

Clinically, the patient presented a right limb with skin changes secondary to previous interventions, with no apparent evidence of signs suggestive of infection (soft tissue and correct sural flap), a valgus deformity at the expense of the tibia and pain in the limb with inability to stand on it (Fig. 1).

* Corresponding author at: C/ Valldemossa, 79, 07120 Palma, Illes Balears, Spain.
E-mail address: jorge.carrion@ssib.es (J. Carrión Martínez).

https://doi.org/10.1016/j.tcr.2022.100718
Accepted 16 October 2022
Available online 17 October 2022

Fig. 1. Preoperative image of the soft tissues. Note the absence of signs of infection, correct sural flap and tibial valgus.

Radiologically, screw breakage and lack of consolidation were observed in the right tibia (Fig. 2). Based on these data and the time of evolution, a diagnosis of aseptic pseudoarthrosis was made. However, given the complexity of the lesion and the previous history of infection, a two-stage surgical treatment was planned.

Initially, the entire implant was removed (except for the five-screw cores that were broken), extensive debridement was performed, samples were taken for microbiology tests and an antibiotic cement spacer (Vancomycin + Gentamicin) was placed. Intraoperatively, the absence of bone callus was observed in more than 70 % of the surface of the tibia, without signs of infection, leaving a circumferential tibial defect of 6.3 cm and a valgus of 8 degrees (Fig. 3).

4 months after surgery, the second surgical stage, bone transport, was performed using a magnetic intramedullary nail (Precice®, NuVasive, San Diego, United States), which consisted of two phases.

During this period of time there were no complications, and the surgical planning of the transport was performed. Using specific software, starting from a 330 mm long tibia with a 63 mm defect, the 320 mm long and 115 mm diameter implant (Precice® intramedullary nail) was selected, which allows transport of up to 70 mm. Likewise, a progressive elongation plan of 0.51 mm per day divided into phases of 0.17 mm each was drawn up (Fig. 4).

Fig. 2. AP and LAT tibial x-rays: failed osteosynthesis with breakage of the proximal screws and pseudoarthrosis of the fracture site.

Surgical procedure

The first phase of the intervention was conducted together with the Plastic Surgery team, who first proceeded to lift the sural flap in order to expose the defect. Subsequently, using specific instruments (Operace® System), the intraosseous screw cores were extracted, the cement spacer was removed, and new debridement and decortication of the bone ends were performed until bleeding bone was obtained. This implied that the previously calculated defect increased to 80 mm, which made it necessary to recalculate and change the length of the definitive implant to a 300 × 11.5 mm nail. Following the surgical technique, under fluoroscopy control, the progressive medullary canal was drilled up to drill of 13 cm of diameter and the implant was inserted to calculate the proximal osteotomy point, which had to be located 7 cm from the proximal end of the nail. Next, the nail was extracted, an osteotomy was performed with a chisel and the implant was reinserted and fixed. Since the transport occurs through an external magnetic device, a distraction and compression test was performed to check the operation of the system (Fig. 5).

Fig. 3. Postoperative x-ray after the first surgical stage: plate removal, cement spacer, partial persistence of the screws.

After surgery

The postoperative period was uneventful. 11 days later, the magnetic distraction process (0.17 mm × 3 times a day) was started. Partial weight bearing with crutches was allowed one month after the intervention. At this time, the patient presented a point of drainage along the edges of the flap that was treated by revision, washing and surgical debridement, with the samples collected being negative for infection. Postoperative evolution was clinically and radiologically satisfactory.

The decision to allow weight bearing depends, among other factors, on the selected implant. The 10 mm diameter nails allow a maximum load of 11 kg, those of 11.5 mm 91 kg of load and those of 13 mm up to 114 kg. In addition, the patient's weight and his/her ability to regulate weight bearing are also aspects that must be considered. In our case, since we had an 11.5 mm implant and our patient behaved responsibly, there was no contraindication to restrict the load.

5 months after the implantation of the nail, the second phase called "Docking" was conducted, which consists of making contact between the transported and the distal fragment. To make that possible, it was required to removing the intercalated screw (the one that fixes the transported fragment) and placing it again 1 cm proximally in that same fragment in order to be able to reset the system and continue with the transport. In addition, in the same process, we did a new debridement of the focus, and an iliac crest autograft was provided to stimulate consolidation at that level (Fig. 6).

In the postoperative period, the patient began bearing partial weight the first month. From the second month on, he started full weight bearing without assistive devices. No incidents were observed during the follow-up and the patient presented a favourable evolution in the following months. After 9 months, signs of bone consolidation were observed, which was complete 16 months after the intervention (Fig. 7).

After 2 years and 8 months, the evolution has been favourable and the patient performs his usual physical activity (mountain cycling) without pain or other complications. As a sequela, the patient presents a dysmetria of approximately 4.5 cm of shortening with respect to the contralateral leg, which he compensates by using a lift without major restrictions (Fig. 8).

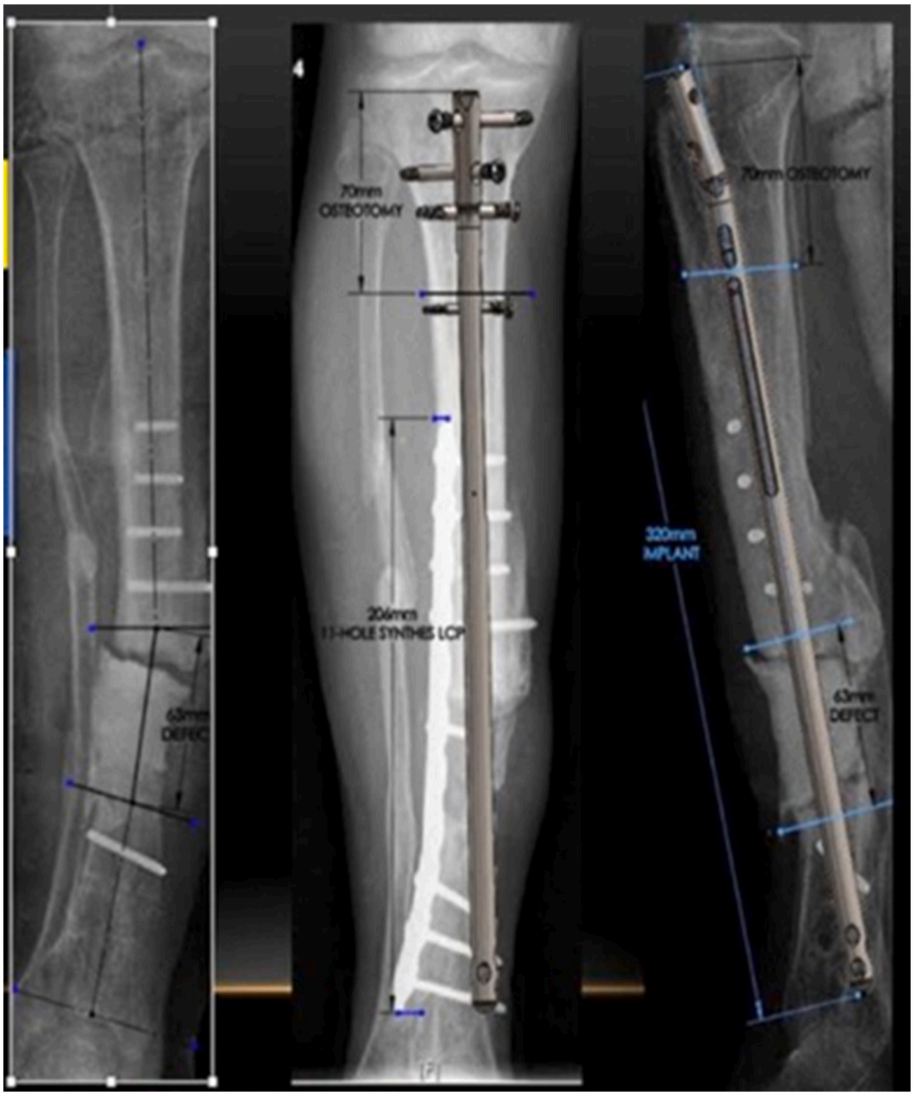

Fig. 4. Preoperative implant planning. 63 mm tibial defect. Selection of 300 mm implant. Osteotomy site 70 mm from the proximal end of the nail.

Discussion

Numerous techniques have been described for the transport of segmental bone defects, including the use of autografts (free or vascularised) or bone allografts, the performance of bone transports with circular (Ilizarov) or monolateral fixators and intramedullary nail, Masquelet technique or distraction osteogenesis and even more modern techniques, such as plate-assisted bone transport (PABST) [1–4]. All of them are effective in treating these defects. In our case, the use of a vascularised fibular autograft was ruled out since both had suffered fractures. On the other hand, amputation was not an acceptable option for our patient.

In recent years, these new bone transport techniques have gained popularity through the use of magnetic intramedullary nails, although there are currently few studies that discuss this type of technique. The most widely used combination with this type of material is plate-assisted bone segment transport (PABST). In these cases, the use of intramedullary nails avoids the complications associated with the use of external fixators: pain, skin lesions, infection of the pins, fractures when removing them, etc. Furthermore, distraction with the nail allows for controlled osteogenesis at the osteotomy without damaging the adjacent soft tissues. The plate is used to stabilise concomitant condylar and metaphyseal fractures, maintain limb length, and facilitate fixation at the anchor point.

When reviewing the associated literature, we found studies where femoral defects from 4.8 to 16 cm and tibial defects of up to 12 cm were corrected [5–8]. Therefore, this technique seems to be a valid solution for the treatment of diaphyseal bone defects in the femur and the tibia. In our case, this option was rejected because it was more aggressive with the soft tissues and due to the rupture of the previous plate.

In the particular case of our patient, we opted for this new implant, based on the use of a magnetic intramedullary nail that does not

Fig. 5. A) Nail implantation after debridement B) Osteotomy line C) Distraction-compression test with an elongation device D) Immediate post-operative radiological control.

require assistance with a plate or external fixation, this being an advantage over the previously mentioned systems.

These nails use an external magnetic system for moving the fragment to be transported, which can be controlled by the patient himself. Different models are currently available, all capable of performing transports of up to 10 cm. After our review, we observed that only Kold S. et al. included in their recent article 2 cases similar to the one presented, which were solved in the same way with a satisfactory result also similar to that of our case [9].

Considering the different options, it was decided to choose the bone transport technique through the use of the magnetic intramedullary nail that is presented in this case, since it allows bone transport to be conducted without the use of external devices, with less damage to soft tissues and allowing early weight bearing by the patient.

Conclusion

Bone transport with a magnetic intramedullary nail seems to be a new and valid option to correct bone defects in long bones. The main advantages of this technique are that the patient can return to his/her daily activities with a high degree of functionality, and without the complications of using external fixators. As disadvantages, it does not allow the correction of the dysmetria, since it only allows the transport of the bone fragment, and it has a high cost, which conditions its low availability in trauma services. With this case we want to show a new alternative for solving complex cases. Despite achieving a more than satisfactory result in all areas of the case (consolidation, functionality and complications), few cases have been reported in the literature. More studies with larger series of patients are required to assess new indications and study the possible long-term complications/implant failures, among others, to compare the different techniques and establish whether there are statistically significant differences between them.

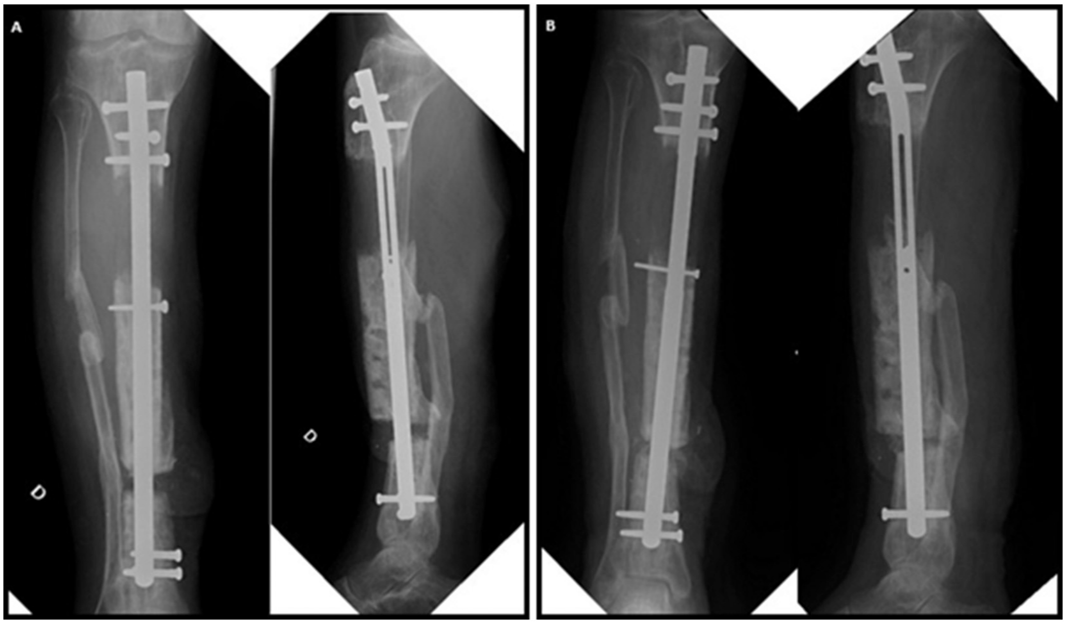

Fig. 6. A) X-ray 5 months after nail implantation, in the preoperative period of the second phase. B) Postoperative X-ray of the second phase ("Docking"), autograft in distal focus is observed.

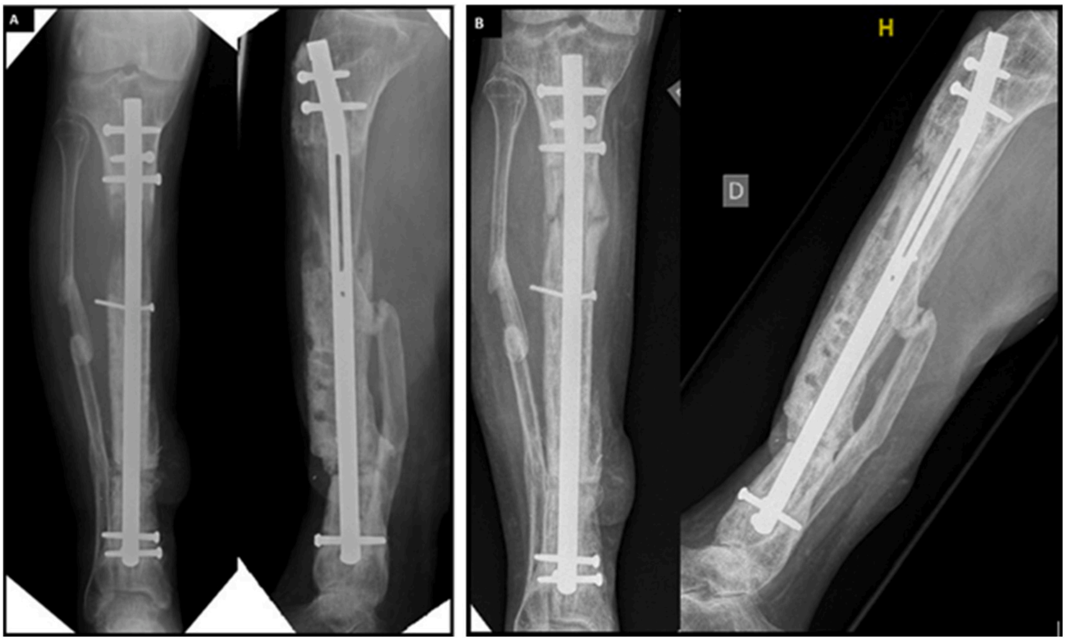

Fig. 7. A) X-ray after 9 months, signs of consolidation in both sites. B) X-ray after 16 months, practically complete consolidation.

Declaration of competing interest

None of the authors do have any financial interest, any other relationship with a commercial company or a conflict of interest related directly or indirectly to this research.

Fig. 8. Control x-ray after 32 months. Complete consolidation is observed.

References

[1] K. Aktuglu, K. Erol, A. Vahabi, Ilizarov bone transport and treatment of critical-sized tibial bone defects: a narrative review, J. Orthop. Traumatol. 20 (1) (2019 Apr 16) 22, https://doi.org/10.1186/s10195-019-0527-1. PMID: 30993461; PMCID: PMC6468024.

[2] D. Paley, D.C. Maar, Ilizarov bone transport treatment for tibial defects, J. Orthop. Trauma 14 (2) (2000 Feb) 76–85, https://doi.org/10.1097/00005131-200002000-00002. PMID: 10716377.

[3] C. Papakostidis, M. Bhandari, P.V. Giannoudis, Distraction osteogenesis in the treatment of long bone defects of the lower limbs: effectiveness, complications and clinical results; a systematic review and meta-analysis, Bone Joint J. 95-B (12) (2013 Dec) 1673–1680, https://doi.org/10.1302/0301-620X.95B12.32385. PMID: 24293599.

[4] V. Chadayammuri, M. Hake, C. Mauffrey, Innovative strategies for the management of long bone infection: a review of the masquelet technique, Patient Saf. Surg. 14 (9) (2015 Oct) 32, https://doi.org/10.1186/s13037-015-0079-0. PMID: 26468329; PMCID: PMC4604613.

[5] S. Summers, M. Krkovic, Bone transport with magnetic intramedullary nails in long bone defects, Eur. J. Orthop. Surg. Traumatol. 31 (6) (2021 Aug) 1243–1252, https://doi.org/10.1007/s00590-020-02854-5. Epub 2020 Dec 24. PMID: 33367945; PMCID: PMC7759217.

[6] A.H. Barakat, J. Sayani, C. O'Dowd-Booth, E. Guryel, Lengthening nails for distraction osteogenesis: a review of current practice and presentation of extended indications, Strategies Trauma Limb Reconstr. 15 (1) (2020 Jan-Apr) 54–61, https://doi.org/10.5005/jp-journals-10080-1451. PMID: 33363643; PMCID: PMC7744668.

[7] U.K. Olesen, T. Nygaard, D.E. Prince, M.P. Gardner, U.M. Singh, M.A. McNally, C.J. Green, J.E. Herzenberg, Plate-assisted bone segment transport with motorized lengthening nails and locking plates: a technique to treat femoral and tibial bone defects, J. Am. Acad. Orthop. Surg. Glob. Res. Rev. 3 (8) (2019 Aug 12), e064, https://doi.org/10.5435/JAAOSGlobal-D-19-00064. PMID: 31592010; PMCID: PMC6754216.

[8] F. Ferner, C. Lutter, J. Dickschas, Retrograder Femursegmenttransportnagel – eine Anwendung bei posttraumatischem Knochendefekt mit Komplexdeformität [Retrograde bone transport nail in a posttraumatic femoral bone defect], German, Unfallchirurg 124 (5) (2021 May) 412–418, https://doi.org/10.1007/s00113-020-00916-1. Epub 2020 Nov 3. PMID: 33141284.

[9] S. Kold, K.S. Christensen, Bone transport of the tibia with a motorized intramedullary lengthening nail–a case report, Acta Orthop. 85 (3) (2014 Jun) 333. PMID: 25061655.