Injury, Int. J. Care Injured 48 (2017) 2285–2291

Contents lists available at ScienceDirect

Injury

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

Original article

Outcome of oscillating saw open osteotomy in two-stage lower extremity bone transport with monolateral frame

Pablo S. Corona[a,1], Luis J. Ramirez-Nuñez[b,*,1], Carles Amat[a], Luis Carrera[a]

[a] Septic and Reconstructive Surgery Unit, Orthopaedic Surgery Department, Vall d'Hebron University Hospital, Universitat Autònoma de Barcelona, Barcelona, Spain
[b] Orthopaedic Surgery Department, Hospital Verge de la Cinta, Tortosa, Spain

ARTICLE INFO

Keywords:
Bone transport
Osteotomy
Distraction osteogenesis
Ilizarov technique
Regenerated bone

ABSTRACT

Introduction: Bone transport techniques have been widely used to solve massive bone defects due to trauma, osteomyelitis or bone tumors. The technique of bone interruption to achieve better new bone formation is a subject of debate. Low-energy osteotomy (LEO) techniques have been proposed as the gold standard. Some authors reject open osteotomy with an oscillating saw (OOS osteotomy), based on the danger of bone tissue thermal necrosis and periosteal damage. To date, however, there is no strong clinical evidence to discourage this high-energy (HEO) bone interruption technique.
Methods: The aim of this study was to determine outcomes in using OOS osteotomy in a series of patients, where monolateral-frame bone transport has been used to resolve segmental bone defects of the lower extremity. The minimum accepted follow-up was 1 year. The primary endpoints were radiographic evidence of regenerated bone quality (*Li classification*) and final outcome (*Cattaneo clinical system* assessment). Further, we analyzed associated complications, and compared results with other published series. We hypothesized that OOS osteotomy produces results no less favorable than those achieved with other, low-energy techniques.
Results: A total of 54 patients, with an average bone defect of 8.58 cm (CI95% 7.01–10.16), were enrolled in the study. In terms of regeneration quality, 84% of the regenerated segment shapes were associated with good outcomes; only 16% exhibited a shape (hypotrophic) predictive of a poor outcome. Regarding functional assessment, following the Cattaneo system, we found a total of 90% good or excellent results. Finally, the Bone Healing Index (BHI) in our series averaged 21.09 days per cm. The main complication observed was pin-track infection, occurring in 45% of the cases.
Conclusion: According our data, the superiority of an LEO technique over HEO techniques is yet to be confirmed; it appears that any open osteotomy is effective, performed well and in a proper clinical setting, and that many factors other than choice of osteotomy technique must play important roles.

Introduction

Limb lengthening and bone transport are techniques based upon the principles of *Callus Distraction Osteogenesis,* popularized by Prof. *Gavriil A. Ilizarov* in the 1950s [1,2]. Distraction osteogenesis (DO) is a term used to describe *de novo* production of bone between corticotomy surfaces undergoing gradual distraction [3,4]. This technique allows bone regeneration, and has been carried out to resolve massive bone defects, cases of non-union, angular deformities and pathological shortening, and even for cosmetic bone elongation [5–7]. In summary, the technique consists of a controlled bone interruption (bone fracture), followed by gradual distraction of the bone segments, classically using an external fixator [8].

Poor regeneration or non-union between the distracted bone segments is one of the most devastating complications that can occur during the DO procedure. Many factors may influence quality and quantity of bone produced during bone transport, such as host and local factors, stability of the external fixation, latency period, optimum lengthening rate and rhythm, etc. [9–11]. However, it has been suggested that the method of bone interruption employed is one of the most significant factors determining quality of the regenerated bone segment [12]. Since the studies of *Ilizarov*, the

* Corresponding author at: Orthopaedic Surgery Department, Hospital Verge de la Cinta, Carrer Esplanetes S/N, 3era Planta, Servicio de Cirugia Ortopedica y Traumatologia, Tarragona, Tortosa 43500, Spain.
E-mail addresses: luisjorn@gmail.com, Luis.ramirez@icatme.com (L.J. Ramirez-Nuñez).
[1] These co-authors contributed equally in producing this paper.

http://dx.doi.org/10.1016/j.injury.2017.07.024
0020-1383/

superiority of a low-energy interruption technique, which minimizes trauma to the periosteum and bone marrow (*corticotomy*) has been promoted [13,14]. Several authors have proclaimed the value of low-energy *osteotomy (LEO)*, where intramedullary bone is violated [15,13]. These authors focus on the importance of low-energy technique, such as use of a chisel or Gigli saw, to avoid thermal necrosis in the bone ends. Theoretically, low-energy bone interruption improves the environment for *DO;* this proposal has been studied in several animal models [13,15], which have shown that open osteotomy techniques produce the greatest damage to the bone [13], and, further, that use of an oscillating saw may lead to delayed consolidation [15]. Thus, low-energy percutaneous osteotomy or corticotomy has been proposed as the gold standard. Some authors reject open osteotomy using an oscillating saw, due to the danger of thermal necrosis of bone tissue, and periosteal damage [8,9,13,15]. However, no strong clinical evidence has been produced to discourage use of open osteotomy with an oscillating saw, and no consensus has been reached as to which technique produces superior quality of regeneration.

In recent years, in our specialty-dedicated unit, open osteotomy using an oscillating saw (OOS osteotomy) has been the technique of choice for bone transport procedures in cases of segmental bone defect. We therefore sought to describe a continuous series of patients who had undergone bone transport which involved open osteotomy using an oscillating saw. Our aims were 1) to determine outcomes following use of this technique, 2) to study associated complications, and 3) to compare results with those in other published series. To our knowledge, this problem has not been specifically and clinically addressed in patients undergoing bone transport using a monolateral frame. We hypothesized that OOS osteotomy achieved results comparable to those achieved with other, low-energy techniques.

Methods

Study design and population

We performed a retrospective review of our prospective institutional database to identify all patients in our center consecutively treated with lower extremity bone transport using a monolateral frame and OOS osteotomy, from 1 January 2010 to 31 December 2014. Our center is situated in a 1000-bed tertiary university hospital, which houses a national-reference musculoskeletal infection unit. Adult patients with bone defects affecting femur or tibia were enrolled in this data set. Patients with no tracking data after surgery were excluded from our study. Patients with bone defects due to excision of tumors or congenital defects were excluded from the study, as were pediatric patients. The study was approved by our center's Ethics Committee (CEIC).

The following data were recorded: a) Demographics, b) Comorbidities, c) Preoperative clinical data: type of primary injury, cause of bone defect (septic non-union or post-traumatic bone defect), number of previous procedures, soft tissue problems, and preoperative microbiological information; d) Intraoperative data: length of bone defect, intraoperative microbiological isolation and susceptibility pattern of the microorganism(s), type of bone transport (anterograde or retrograde) and e) postoperative events and complications.

Operative technique

The procedure is carried out with the patient lying supine on a radiolucent table. The table has independent leg supports, allowing placement of the contralateral extremity in a posterior position, facilitating C-arm use. A tourniquet is not ordinarily used. In cases of infected non-union, a two-stage procedure is always performed. During the first stage, if hardware from a previous surgery is present, that hardware is removed. Dead bone is resected at the limit of apparently healthy bleeding bone, and infected or scarred soft tissues and sinus tracts are adequately debrided. Prior to administration of intraoperative antibiotics, at least 6 samples are taken for culture and histological study. All surgical fields are then thoroughly irrigated with a low-pressure lavage system, using saline solution. After debridement, a monolateral external fixator (*LRS-Limb Reconstruction System*®, Orthofix, Verona, Italy) with hydroxyapatite-coated half-pins (*X-Caliber*®, Orthofix, Verona, Italy) is applied. The residual bone defect is assessed, and an antibiotic spacer is placed in the bone gap (Fig. 1A and B). Postoperative antibiotic treatment is indicated, following the advice of a specialty-dedicated infectious disease consultant and microbiologist.

According to our protocol, the second-stage procedure is performed after a minimum of 6 weeks under tailored systemic antibiotic treatment, and when CRP/ESR levels have returned to normal. During the second stage, the spacer is extracted, followed by new debridement and sampling; an OOS osteotomy is performed according to a strict protocol. The osteotomy may be proximal to the bone defect (*antegrade transport*), or distal to it

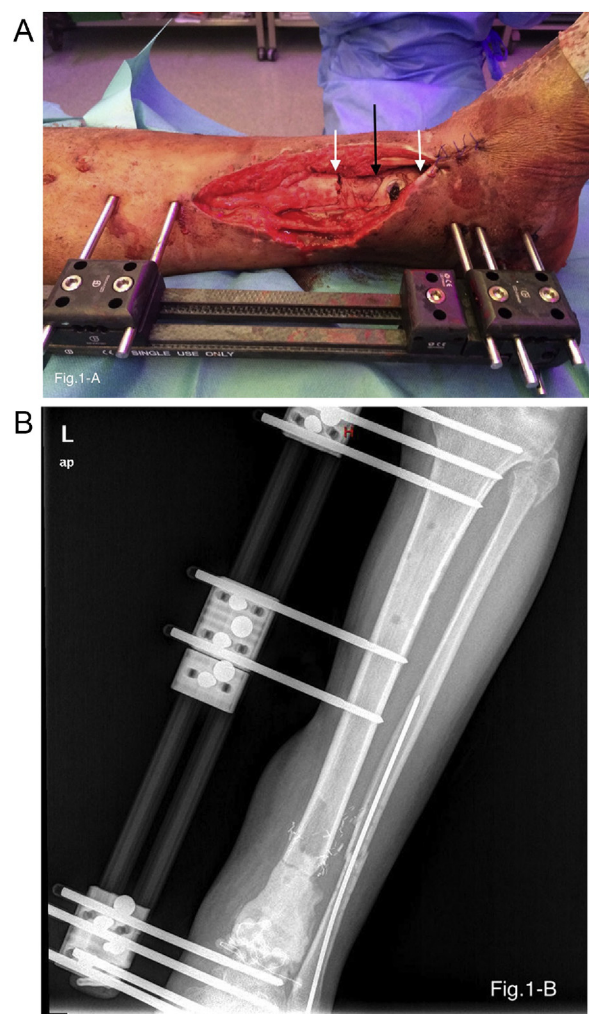

Fig. 1. The image shows a post-osteomyelitic segmental bone defect over the distal tibia (Left Tibia). After bone resection and monolateral frame (*LRS-Orthofix*) placement, an antibiotic-loaded cement spacer is used to fill the void (***1A***). A radiograph of the same case, showing the frame positioned to perform an anterograde bone transport, to achieve ankle fusion (***1B***).