

# Comparative Outcomes of Bone Shortening versus Bone Transport in the Management of Bone Defects: A Literature Review

Dandy Drestanto Adiwignyo<sup>1</sup>, Istan Irmansyah Irsan<sup>1</sup>,  
Thomas Erwin Christian Junus Huwae<sup>1</sup>, Syaifullah Asmiragani<sup>1</sup>,  
Satria Pandu Persada Isma<sup>1</sup>, Muhammad Abduh<sup>1</sup>

<sup>1</sup>Department of Orthopaedic and Traumatology, Faculty of Medicine, Universitas Brawijaya – Dr. Saiful Anwar General Hospital

Corresponding Author: Dandy Drestanto Adiwignyo

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## ABSTRACT

Segmental bone defects, particularly in weight-bearing bones such as the tibia and femur, present significant challenges in reconstructive orthopaedics. These defects can result from trauma, infections, tumor resections, or non-unions after failed surgeries. Bone grafting is often inadequate for large defects, leading to the adoption of distraction osteogenesis (DO) techniques, specifically acute shortening with subsequent re-lengthening (ASR) and bone transport (BT). This literature review compares the outcomes of ASR and BT in managing bone defects, focusing on treatment duration, complication rates, and functional outcomes. ASR involves shortening the bone to close the defect, followed by gradual re-lengthening through the process of distraction osteogenesis. In contrast, BT preserves limb length by gradually transporting a bone segment across the defect. Both methods aim to achieve bone union, restore function, and eradicate infection, but their complication profiles differ. ASR offers shorter treatment times, fewer surgeries, and a reduced external fixation index, but it is limited to smaller defects. BT, suitable for larger defects, preserves limb length but requires

longer external fixation and may result in higher rates of docking-site complications. Hybrid approaches combining both techniques are increasingly utilized, allowing for infection control and soft-tissue closure with ASR followed by BT or re-lengthening. Ultimately, treatment selection should be tailored to the defect's size, location, vascular condition, and soft-tissue status. Evidence supports ASR for smaller defects and modern BT modifications for larger or more complex cases.

**Keywords:** acute shortening, bone transport, Ilizarov technique

## INTRODUCTION

Segmental bone defects, particularly in weight-bearing bones such as the tibia and femur, are among the most complex challenges in reconstructive orthopaedics. These defects can result from severe open fractures, infections, tumor resections, or non-union following failed surgeries. [1,2] With advances in trauma care and surgical techniques, the incidence of these defects has increased, placing significant demands on the reconstructive and regenerative capabilities of orthopaedic surgeons. Traditionally, bone grafting techniques were the mainstay of treatment for these defects.

However, bone grafting is often insufficient when large defects are present, due to limitations in graft availability, the risk of donor site morbidity, and complications such as graft resorption and non-union.<sup>[3]</sup>

As an alternative, distraction osteogenesis (DO), initially introduced by Ilizarov, has become a critical method for managing bone defects, as it allows for the gradual regeneration of bone and soft tissue.<sup>[2,4]</sup> The technique utilizes mechanical tension applied to bone fragments via an external fixation device, resulting in the formation of new bone in the gap created by the distraction.<sup>[2]</sup> This technique has been adapted for a variety of indications, including limb lengthening, the treatment of non-unions, and the management of bone defects.<sup>[5]</sup> Among the various forms of distraction osteogenesis, two primary methods have emerged as the most widely used for treating bone defects: acute shortening with subsequent re-lengthening (ASR) and bone transport (BT).<sup>[6]</sup>

ASR involves initially shortening the bone to close the defect and subsequently re-lengthening the limb through distraction osteogenesis. In contrast, BT consists in creating a transport segment of bone, which is moved across the defect until it docks at the opposite side, thereby preserving the length of the limb during the process.<sup>[7]</sup> While both methods aim to achieve the same core objectives—bone union, functional restoration, infection eradication, and limb length preservation—their approaches, technical executions, and complication profiles differ substantially.<sup>[8]</sup> Over the past few decades, a growing body of literature has compared the outcomes of these two techniques, evaluating factors such as treatment duration, complication rates, functional outcomes, and the overall burden on patients.<sup>[9-11]</sup> Recent meta-analyses have provided valuable insights into the advantages and disadvantages of each method, indicating that the choice between ASR and BT should be based on defect size, location, soft tissue condition, and vascular safety.<sup>[6]</sup> For instance, studies

suggest that ASR is most effective for smaller defects ( $\leq 4-5$  cm), whereas BT is preferred for larger defects ( $> 5-6$  cm) and when limb length preservation is critical.<sup>[7,12]</sup>

Despite the growing body of evidence, the optimal technique for different clinical scenarios remains a topic of debate, with some suggesting hybrid approaches that combine aspects of both methods for specific indications. This literature review aims to provide an updated comparison of ASR and BT, summarizing key findings from recent studies and providing guidance on their indications, advantages, and recommendations. By synthesizing the current body of evidence, this review seeks to clarify which technique offers the most reliable outcomes with minimal burden to the patient, thereby guiding clinical decision-making in the management of segmental bone defects.

## LITERATURE REVIEW

### Definition

ASR involves resecting infected or necrotic bone, followed by bringing the healthy bone ends together (shortening) to achieve contact and stability. Later, the lost length is restored by performing a corticotomy at a healthy metaphyseal site and applying gradual distraction osteogenesis. On the other hand, BT creates a controlled osteotomy at a healthy segment, then gradually moves a transport bone segment across the defect until it docks at the opposite side, regenerating new bone at the transport site. Unlike ASR, limb length is preserved throughout the process.<sup>[13,14]</sup>

### PROCEDURE

In ASR, after radical debridement and stabilization with an external fixator, the surgeon acutely or gradually shortens the limb until the bone ends dock. This maneuver can simultaneously close soft-tissue gaps and reduce the need for flap coverage. A corticotomy is then created at a remote, biologically favorable site, and distraction begins after a latency period,

typically at 1 mm/day until original limb length is restored.<sup>[13]</sup>

In BT, a corticotomy is performed, and the transport segment is moved progressively across the defect. The transported bone eventually docks with the distal fragment, where union must occur. Additional procedures, such as bone grafting or revision at the docking site, may be necessary to achieve a solid union. To reduce external fixation time, BT can be combined with intramedullary nails or plates (“transport over nail/plate”) or performed with entirely internal transport nails.<sup>[14]</sup>

**Indication**

Indications for each technique are influenced by the defect size, location, and soft tissue status. ASR is most suitable for small to moderate defects ( $\leq 4-5$  cm), particularly when acute shortening does not

threaten neurovascular structures and when soft-tissue coverage is needed. The method is also valuable in peri-articular regions where bone transport is technically challenging.<sup>[9,11]</sup>

BT is generally preferred for larger defects ( $>5-6$  cm), cases with preserved fibula providing stability, or when vascular compromise prevents acute shortening. Internal BT devices have expanded indications by reducing external frame-related complications, making BT increasingly feasible for both tibial and femoral reconstructions.<sup>[9,11,14]</sup>

**Advantages and Disadvantages**

Studies consistently demonstrate similar union and infection eradication rates between ASR/SR and BT, but the complication patterns differ. The advantages and disadvantages are shown in Table 1.

**Table 1. Advantages and Disadvantages between acute shortening with subsequent re-lengthening (ASR/SR) and bone transport (BT)** <sup>[9,13]</sup>

	<b>Advantages</b>	<b>Disadvantages</b>
<b>ASR/SR</b>	<ol style="list-style-type: none"> <li>1. Shorter external fixation time and lower external fixation index (EFI).</li> <li>2. Reduced number of additional surgeries, especially at the docking site.</li> <li>3. Ability to facilitate soft-tissue closure by shortening, often avoiding flap procedures.</li> <li>4. Modern modifications, such as shortening and re-lengthening combined with intramedullary nailing (SRN), further reduce treatment duration and complication rates.</li> </ol>	<ol style="list-style-type: none"> <li>1. Limited to more minor defects due to the risk of vascular compromise or limb malalignment if excessive shortening is attempted.</li> <li>2. Frequently requires bone grafting at the docking site.</li> </ol>
<b>BT</b>	<ol style="list-style-type: none"> <li>1. Capable of managing extensive defects without acute vascular risk.</li> <li>2. Preserves limb length throughout the process.</li> <li>3. Internal transport devices or “transport over nail” techniques reduce frame-related morbidity.</li> </ol>	<ol style="list-style-type: none"> <li>1. Longer external fixation times in classical forms.</li> <li>2. Higher incidence of docking-site problems, often requiring bone grafting or revision (up to two-thirds of cases in some studies).</li> <li>3. Frame-related complications such as pin-site infection, joint stiffness, and patient discomfort.</li> </ol>

Previous meta-analyses have confirmed these trends: acute shortening provides faster docking-site healing and lower EFI, while BT is associated with fewer cases needing docking-site bone graft but with higher unplanned reoperations.<sup>[6]</sup>

**Recommendation**

- For small to moderate defects with safe shortening and acceptable soft-tissue conditions, ASR/SR is the recommended option due to shorter treatment duration, fewer unplanned surgeries, and reliable union. This is particularly true in the tibia and femur

when combined with intramedullary fixation. <sup>[9,11]</sup>

- For larger defects or when acute shortening poses vascular risks, BT remains the method of choice. Its utility increases when internal transport devices are available, significantly reducing external fixation time. <sup>[9,11]</sup>
- For peri-articular or distal tibial defects, modified ASR approaches using intramedullary nails or hybrid constructs appear superior, reducing complications, external fixation time, and psychological burden on patients compared with BT. <sup>[9,11]</sup>
- In modern practice, combining both methods are common: initial shortening for infection control and soft-tissue closure, followed by limited transport or re-lengthening as needed. This hybrid approach exploits the advantages of each.

## CONCLUSION

Both Acute Shortening with Subsequent Re-lengthening (ASR) and Bone Transport (BT) are effective methods for managing segmental bone defects, with each offering distinct advantages and challenges. ASR provides shorter treatment times and fewer surgeries, making it ideal for smaller defects ( $\leq 4-5$  cm), but is limited by the risk of vascular compromise and limb malalignment. BT is better suited for larger defects ( $> 5-6$  cm), preserving limb length but often requiring longer external fixation and additional surgeries, particularly at the docking site. Although both techniques achieve similar union rates and functional outcomes, the choice between ASR and BT should depend on defect size, vascular safety, and soft tissue conditions. ASR is preferred for smaller defects, while BT is favored for larger or more complex cases. Hybrid approaches combining both methods may also offer tailored solutions. Future research should focus on optimizing these techniques and exploring hybrid strategies to improve patient outcomes further.

## Declaration by Authors

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