Trabexus®

Trabecular Osteoinductive Biocement†

Clinical Report

Real World Case Series from a Busy Community Hospital Trauma Practice

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ABSTRACT

Critical-sized bone defects requiring supplemental grafting are frequently encountered in orthopedic trauma practice. In order to properly heal these bone defects, the resultant voids must be filled with bone graft or substitute materials to facilitate bone healing and prevent infiltration of non-osseous fibrous tissue. In response to the inherent drawbacks of autologous bone graft (e.g. supply limitations, variable quality, additional operative time, patient morbidity), synthetic bone graft substitutes have been developed and are available for clinical use. However, despite the abundance of an array of bone graft substitutes, the quest for an ideal bone graft remains elusive.

The practice of orthopedic trauma surgery creates challenging demands for bone graft substitutes. Ideally, bone graft substitutes should exhibit excellence across a multitude of product characteristics including mechanical strength, remodeling profile and intraoperative handling, along with being readily available off-the-shelf. From a biomechanical perspective, an ideal bone graft must have sufficient mechanical strength, exceeding that of adjacent cancellous bone. Moreover, the material's biomechanical strength should be durable, maintaining its integrity during the bone healing process. Remodeling characteristics of the bone graft substitute are also important. An ideal bone graft should remodel at a rate in concert with the formation of new bone, not resorbing too quickly and creating a new bone void, or resorbing too slowly and serving as an impediment to new bone formation. Superior intraoperative performance and handling is also paramount. The ideal material would have versatile handling properties, permitting material placement manually, or through a minimally invasive technique and be visible during injection under fluoroscopy. Lastly, product availability and "operating room readiness" should not be discounted. Ideal bone graft substitute products should not require specialized storage conditions or complicated preparatory steps.

A new bone graft substitute (Trabexus®, Vivorté, Louisville, KY) has been developed that encompasses many of the characteristics of an ideal bone graft substitute. The purpose of this review was to evaluate the clinical performance and safety of Trabexus in a cohort of "real world" cases and illuminate the product's suitability in a typical orthopedic trauma practice.

INTRODUCTION

Trabexus® is a proprietary, biocompatible, gradually resorbable matrix comprised of calcium phosphate and engineered allograft bone particles. Upon mixing, the product components form a self-setting paste that solidifies to a compressive strength of up to 25MPa. This compressive strength is significantly higher than other cements of similar composition.[1] Trabexus can be implanted manually or extruded through a cannula to apply the material in a minimally invasive and controlled manner. Further, Trabexus exhibits high radiopacity, enabling precise placement under fluoroscopy.

A key feature of Trabexus is the thoughtful design of the allograft component. The allograft particles within Trabexus are formed into "hourglass" shapes using a proprietary manufacturing process. The particles are also partially demineralized, exposing osteoinductive factors that can influence and direct bone repair. The novel shape increases the "interconnectivity" of adjacent particles (shown below) while the surface demineralization enhances the remodeling of the allograft component. As a result, the allograft remodels more rapidly than the surrounding cement, creating an extensive network of channels that enhances remodeling of the overall construct and effectively provides an internal trabecular architecture for bone formation.

A. B.

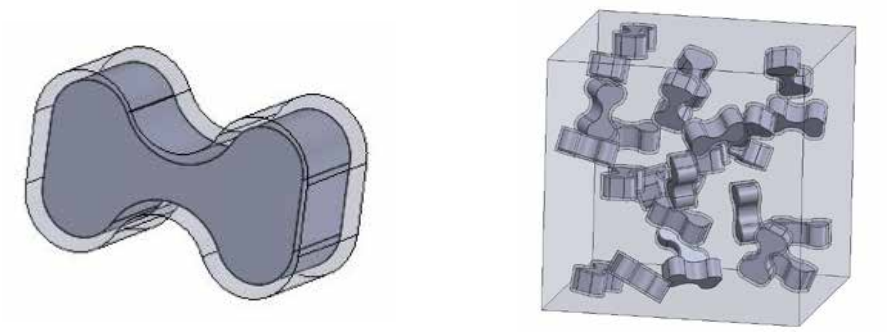


Figure 1. A. Rendering of TRAB™ particle (surface demineralization depicted in light grey). B. TRABS are optimally designed to "interconnect" with adjacent particles within a volume of cement and extend to the boundary of the defect, promoting new bone infiltration.

MATERIALS & METHODS

Six (6) patients presented with bone fractures and non-unions routinely observed within a busy orthopedic trauma practice. In each case, bony voids subsequent to injury or surgery required bone grafting. In place of autograft, each void was filled with a novel bone graft substitute (Trabexus®, Vivorté, Louisville, KY) to avoid the increased operative time and patient morbidity associated with harvesting autograft.

For all patients, Trabexus was prepared in accordance with the product's instructions for use. The contents are enclosed in multi-compartment, sterile, single-use kit convenient for surgical use. The allograft component (i.e. TRABS) are first added to the dry powder and mixed. Then, the liquid component (which contains a setting catalyst solution) is added and mixed for 60 seconds at which time Trabexus is ready for application into the bony defect. As needed, the material can be manipulated for an additional 3.5 minutes of working time.

In this case series, Trabexus was implanted using a minimally invasive technique using the provided cannula. Following the working time period, the cement begins to harden. Full hardness is typically achieved in 8-10 minutes, however up to 15 minutes of elapsed time may be required depending on individual patient/clinical circumstances.

Setting of Trabexus is isothermic and therefore will not elicit cytotoxic thermal damage to surrounding tissues. Upon setting the ceramic component of Trabexus converts to hydroxyapatite, which is consistent with the mineral phase of normal human bone.[2]

RESULTS

All patients were surgically treated with curettage and bone grafting. Trabexus was implanted in all cases and was easy to prepare, mix and deliver to the surgical site, making it highly-compatible with the demands of the surgical environment. The post-operative performance of Trabexus was also excellent, as there was no evidence of any inflammatory response, infection, device migration or other device-related complication in this case series.

Table 1: Clinical indications and patient characteristics

Patient	Indication	Patient Age	Compromising Patient Factors
1	Ankle arthrodesis	63	Revision procedure Uncontrolled diabetes Heavy smoker
2	Subtalar arthrodesis	66	Severe osteoarthritis Foot deformity
3	Humeral fracture	68	Fracture nonunion Diabetes End stage renal disease
4	Phalanx fracture	47	Pathologic fracture secondary to bone lytic tumor
5	Ankle arthroplasty	56	Revision procedure Uncontrolled diabetes Heavy smoker
6	Distal radius fracture	48	Revision procedure

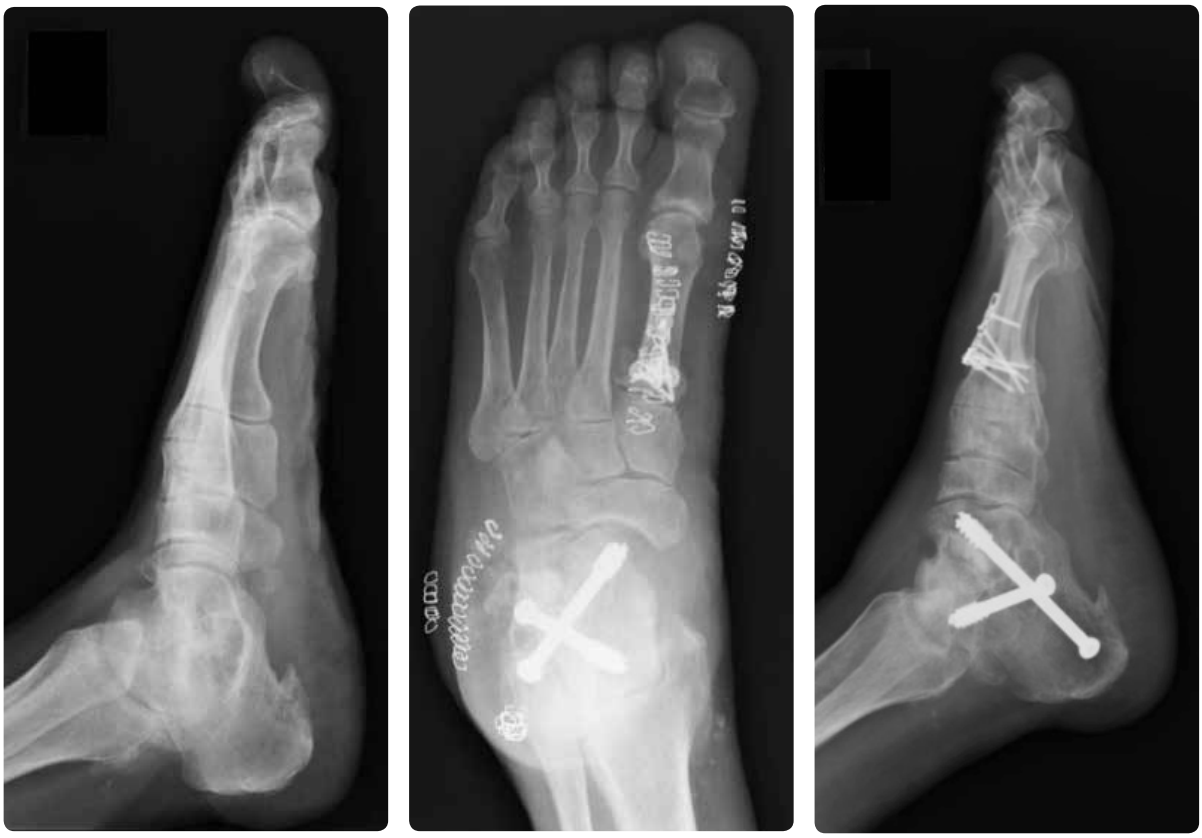
Patient 1

63-year old male presented with failed left ankle arthrodesis following five prior lower extremity surgeries. Patient indicated for hardware removal, exchange nailing and pantalar arthrodesis supplemented with Trabexus. Patient exhibited solid fusion one year post-operative and was ambulatory without physical assistance. Patient recovery was uneventful despite presence of uncontrolled diabetes mellitus and history of heavy smoking.

Figure 2. Pre-operative radiograph shows the presence of distinct lucency at the tibiotalar joint, despite prior surgical history. In contrast, the one-year post-operative films provide evidence of radiographic of union across the hindfoot.

Patient 2

66-year old female presented with severe subtalar osteoarthritis, flatfoot deformity and hallux valgus of the great toe. Patient indicated for subtalar arthrodesis supplemented with Trabexus. Patient exhibited solid fusion four months post-operative, along with improved alignment of the arch and corrected hallux valgus. Patient is walking pain free without use of any assistive devices.

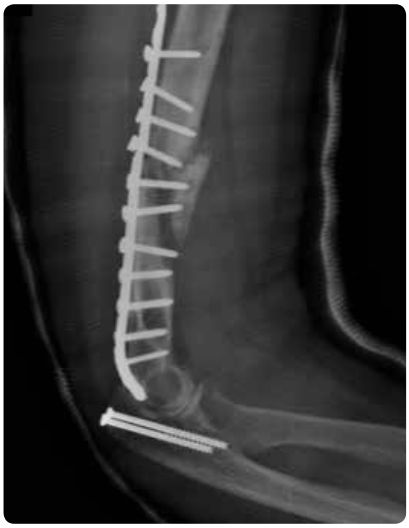


Pre-Operative | Immediate Post-Operative | 4 Months Post-Operative

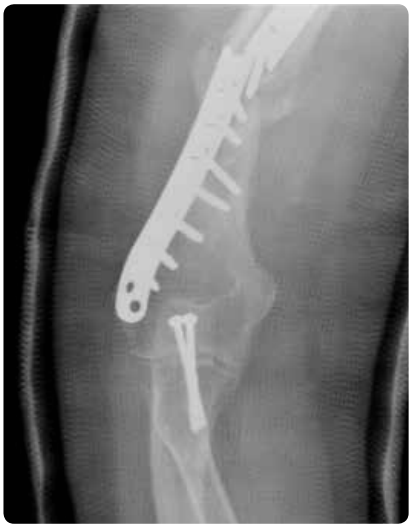
Figure 3. Fusion sites healed without complication or evidence of inflammation or other device-related sensitivity.

Patient 3

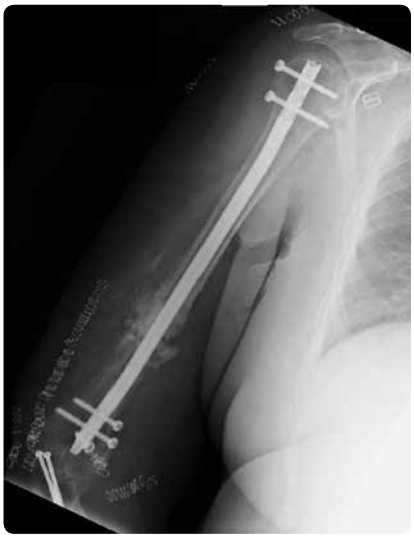
68-year old female presented with hardware failure and distal humeral nonunion. Patient also had underlying COPD, diabetes mellitus and end stage renal disease. Patient indicated for exchange nailing supplemented with Trabexus. Patient exhibited solid union nine months post-operative with good function of the affected upper extremity.



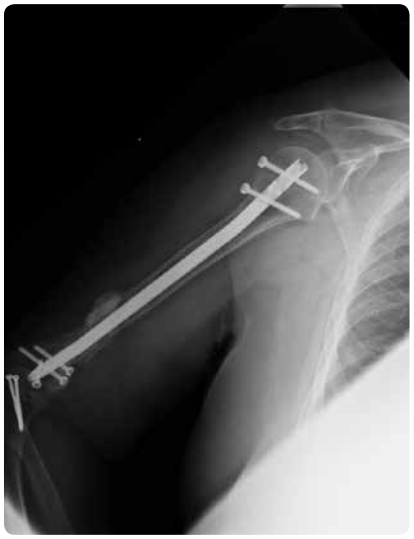
Pre-Operative



Pre-Operative



Immediate Post-Operative

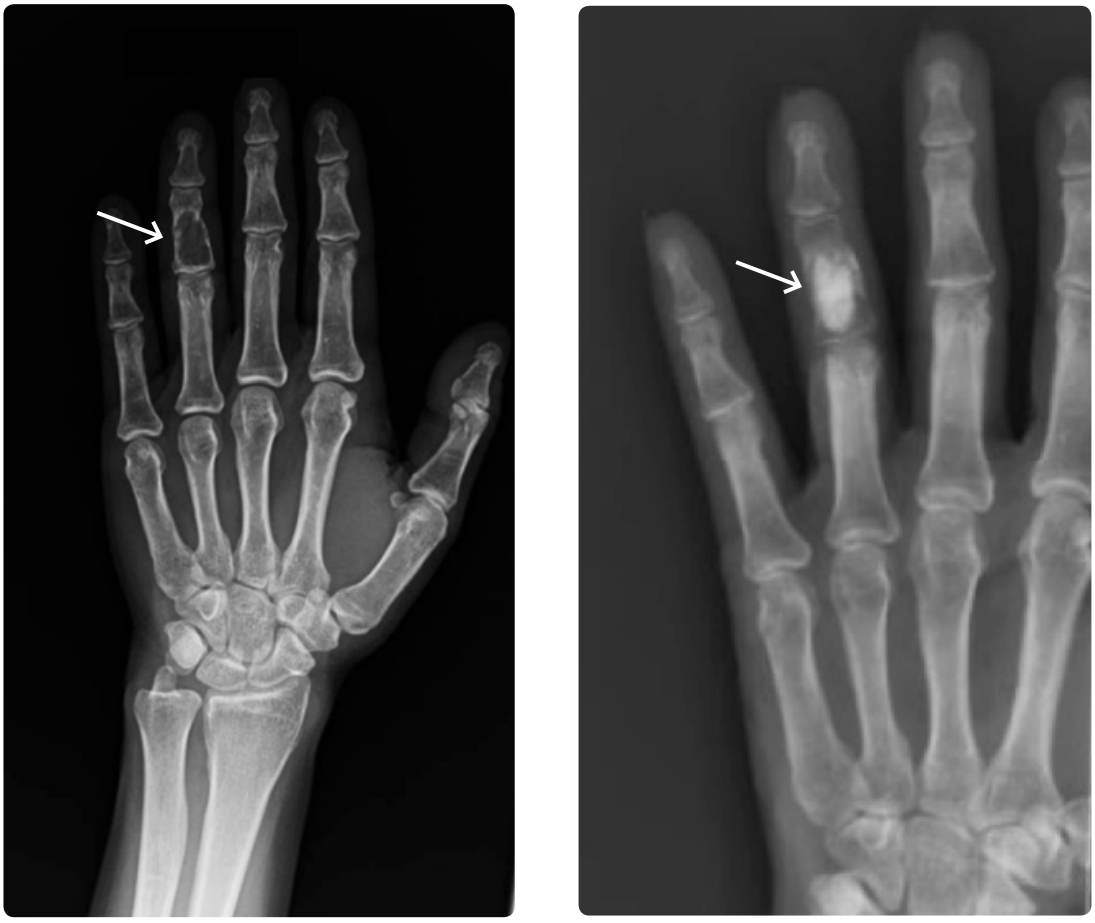


9 Months Post-Operative

Figure 4. Pre-operative radiographs illustrate the extent of the initial injury. Trabexus is visible post-operatively in the distal humerus, however by nine months the bone graft mass has substantially remodeled.

Patient 4

47-year old female presented with a pathologic fracture of the 4th middle phalanx, resulting from the presence of a bone lytic tumor. Patient indicated for tumor excision and bone grafting with Trabexus. Patient exhibited good healing progression two months post-operative. Trabexus demonstrates a high degree of radiopacity, which is an inherent characteristic of the material formulation.

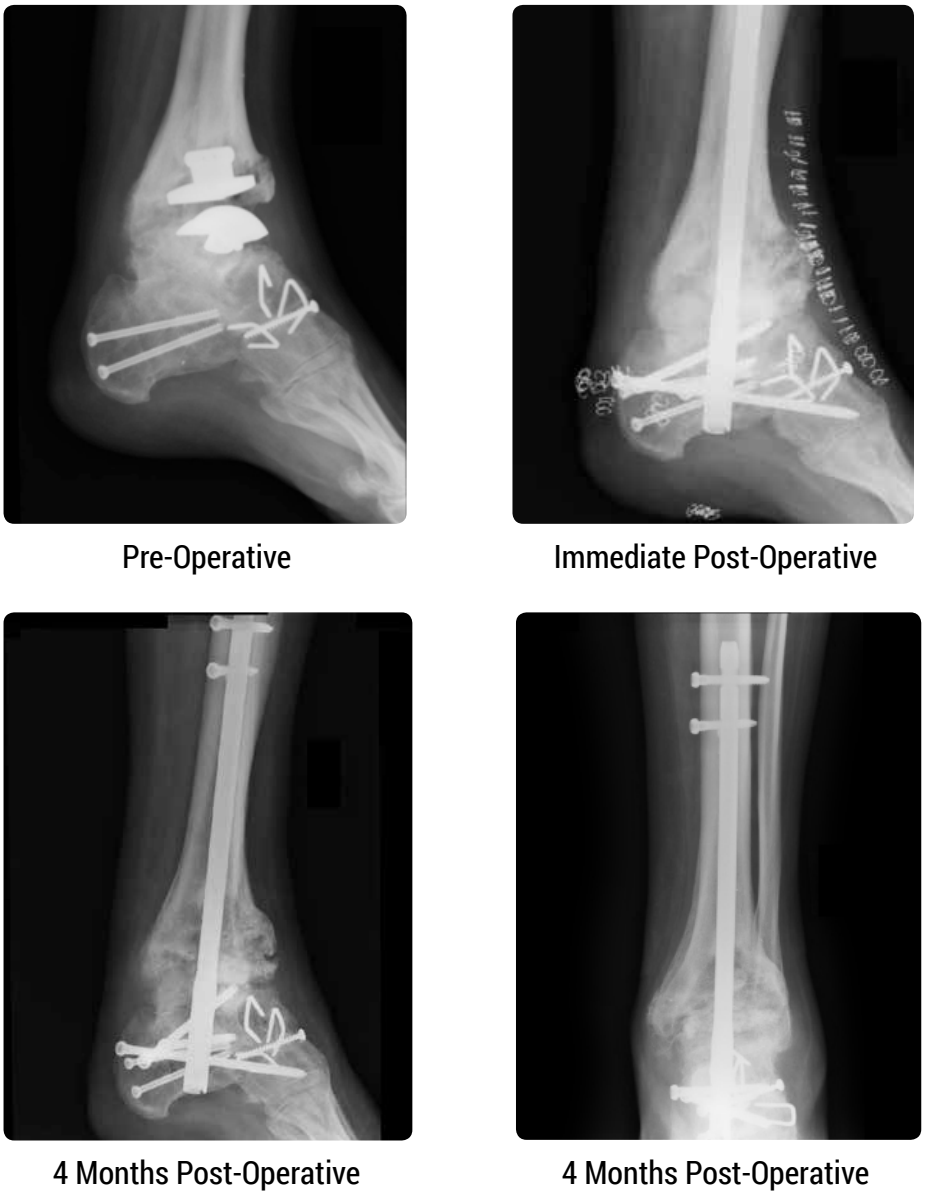


Pre-Operative | 2 Months Post Operative

Figure 5. Pre-operative radiograph clearly shows the presence of osteolytic lesion within the phalanx. Trabexus completely fills and conforms to the shape of the cavitary defect, along with demonstrating a high degree of radiopacity, which is an inherent characteristic of the material formulation.

Patient 5

56-year old male presented with failed left total ankle arthroplasty. Patient indicated for hardware removal and pantalar arthrodesis with bone allograft and Trabexus. Patient exhibited solid union four months post-operative, despite underlying uncontrolled diabetes and smoking habit. Patient is pain-free and ambulatory without the use any assistive devices.



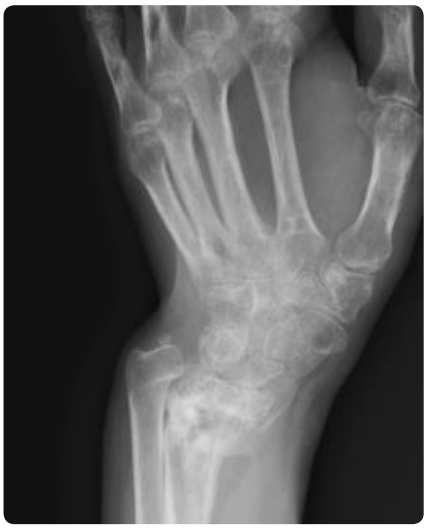
Pre-Operative | Immediate Post-Operative

4 Months Post-Operative | 4 Months Post-Operative

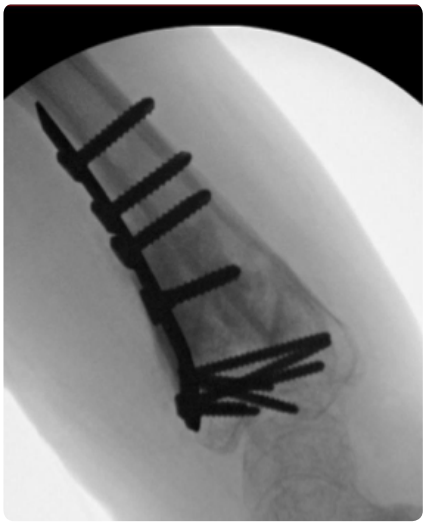
Figure 6. Post-operative radiographs demonstrate robust healing and callus formation across the fusion construct.

Patient 6

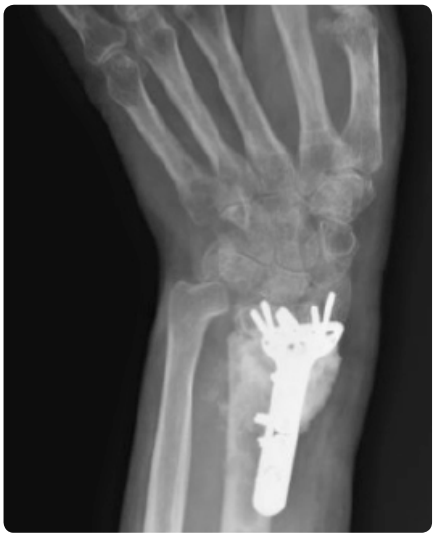
48-year old male presented with left distal radius nonunion. Patient indicated for open reduction and internal fixation with volar plate supplemented by allograft bone and Trabexus. One month post-operative, fracture healing is evident and patient resumed use of left extremity for activities of daily life.



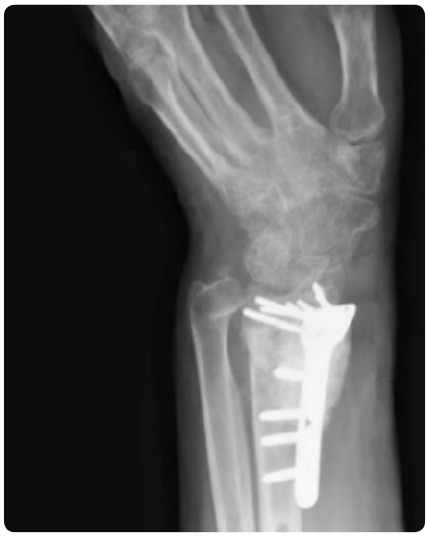
Pre-Operative



Immediate Post-Operative



1 Month Follow-Up



1 Month Follow-Up

Figure 7. Patient exhibited functional improvement and significantly improved alignment one month post-operative.

DISCUSSION

Trabexus® demonstrated meaningful clinical utility in this cohort of clinical patients. Trabexus is available off-the-shelf and does not require any special handling, such as cold storage or refrigeration. Preparing the graft is straightforward, and is ready for implantation following 60 seconds of mixing. Due to its composition, Trabexus is highly radiopaque and requires no additional radiopacifiers or contrast agents to ensure visibility under fluoroscopy. Further, the graft may be implanted manually, or extruded through a cannula for precise delivery to the surgical site. Upon implantation, the graft solidifies isothermically, without generating heat that could potentially harm adjacent tissue.[1] Trabexus does not swell or expand during setting[1], a condition that could lead to pressurization of the implant or extravasation of the material outside the intended delivery area. Importantly, Trabexus obviates the need for harvesting autogenous bone graft and thus reduces overall operative time and the potential for post-operative complications.

The ideal bone graft substitute should be stronger than cancellous bone throughout the entire healing process. If at any point in time, the compressive strength drops below that of cancellous bone (~5 MPa)[3], undesired stresses may be imposed and mechanical requirements for these applications may be compromised. Trabexus' optimized formulation of calcium phosphate and partially demineralized allograft results in a solidified construct with a compressive strength of up to 25 MPa.[1] Remodeling of Trabexus occurs gradually, at a rate slower than calcium sulfate containing materials, which often resorb more quickly than new bone can form in its place, yet more rapidly than purely synthetic cements that may take years to completely remodel.[4] As designed, Trabexus strikes a unique balance of compressive strength and remodeling rate.

To conclude, Trabexus performed well in this small patient series of cases seen within a typical orthopedic trauma practice. Despite the presence of comorbid conditions within this population, patients exhibited solid union and restored function to the affected site. Following surgery, patient pain markedly improved, and there was no inflammatory response, infection or reoperation as a result of Trabexus implantation. The material has attractive handling and intraoperative characteristics and appeared to remodel normally in these patients, without contributing to patient morbidity or post-operative complications. Although further longer follow up is desired to see full resorption in these patients, radiographic imaging and clinical follow up demonstrate the product's safety and effectiveness for use as a novel bone void filler in these applications.

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†Allograft component demonstrated osteoinductivity in athymic mouse model submitted in support of 510(k) clearance (K143547)

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