Absorbable Biologically Based Internal Fixation

Ahmed M.S. Ibrahim, MD[a], Pieter G.L. Koolen, MD[a], Kuylhee Kim, MD[a], Gabe S. Perrone, MSc[b], David L. Kaplan, PhD[b], Samuel J. Lin, MD[a,*]

KEYWORDS

• Absorbable • Biologics • Silk • Polylactic acid • Polyglycolic acid • Fracture • Screw • Pins

KEY POINTS

- Absorbable internal fixation has advanced to become a potential reliable alternative to metallic devices.
- The most commonly used materials for absorbable fixation are polyglycolic acid (Biofix), a copolymer of polyglycolic and polylactic acid (Polyglactin 910), and polyparadioxanone (Orthosorb).
- Intrinsically stable fractures protected with casts or other modalities may be adequately managed with absorbable devices.
- Unstable foot and ankle fractures where a screw or pin is subjected to repetitive shear forces should not be treated with absorbable devices; fixation failure may result.
- New options for absorbable devices made from silk may be able to overcome current limitations and address a broader range of fixation needs.

INTRODUCTION

Materials used for the repair of bone can categorized as either natural or synthetic. Natural materials include bone, derivatives of bone, collagen (a natural polymer), and surgical gut. Synthetic materials are classified as either nonabsorbable, such as metals and metal alloys, or absorbable, which consist of ceramics and polymers.[1] Several types of absorbable internal fixation devices have been used, and the most successful are composed of alpha polyesters. The most commonly used polyesters are polyglycolic acid (PGA) marketed as Biofix, a copolymer of PGA and polylactic acid (PLA) known as Polyglactin 910, and polyparadioxanone (PDS), frequently recognized as Orthosorb.[2–4] Other materials used as fixation implants or as coatings on one

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[a] Division of Plastic Surgery, Department of Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, 110 Francis Street, Boston, MA 02215, USA; [b] Department of Biomedical Engineering, Tufts University, 4 Colby Street, Medford, MA 02155, USA
* Corresponding author. 110 Francis Street, Lowry Suite 5A, Boston, MA 02215.
E-mail address: sjlin@bidmc.harvard.edu

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of the alpha polyesters include a 4-component fibrin sealant called poly-beta-hydroxy butyric acid, bone cement (*n*-butyl-2-cyanoacrylate), and acrylic and bis-GMA plastics with acrylic emulsion or dispersion.[5]

The use of absorbable biomaterials for the repair of fractures has been studied and characterized since the late 1960s.[6,7] Numerous successful clinical applications have been described, including repair of osteochondral fractures, osteochondritis dissecans of the knee, phalangeal fractures, and in arthrodesis procedures of the hand.[6] Recently, these devices have been implemented for internal fixation in the foot.[5,6] Biomaterials absorb after implantation, resulting in a gradual transfer of mechanical stress from the device to surrounding tissues. In this way, stress shielding is reduced over time.[7] They are also radiolucent, making them useful when assessing osteotomy position or fracture healing. Furthermore, they eliminate the need for removal of hardware, saving on the additional health care costs of a second operation.[7]

Despite the advantages of absorbable biomaterials, there are some disadvantages. Thus far, they have proven to be weaker than nonabsorbable fixation systems.[8] In general, most absorbable devices retain their strength for up to 8 weeks but lose it before being completely absorbed. Current iterations of absorbable devices on the market have also been reported to induce osteolysis, sterile sinus formation, and fibrous encapsulation.[9,10] These attributes have been attributed to their rapid breakdown. To counteract this issue, copolymers have been incorporated to slow down the breakdown process, allowing degradation to occur over a period of months to years rather than weeks.[7,11,12] Indeed, there is progress being made; a recent study in which absorbable screws were manufactured from silk demonstrated comparable mechanical properties to their titanium counterparts and an ability to last an average of 7 months.[13] **Table 1** compares the pros and cons of different fracture fixation

Table 1
Comparison of metallic, current absorbable, and silk fixation systems

Material Used	Advantages	Disadvantages
Metallic	Easy implantation Robust mechanical properties Resterilization	Stress shielding Temperature sensitivity Plate exposure or migration Growth disturbance in children Palpability Limited radiologic imaging Infection
Current absorbable (PLA, PGA, PLGA)	Fully degradable to avoid need for hardware removal Limited stress shielding: Improved bone remodeling and accelerated healing owing to micromotion of devices Flexibility for growing bones	Laborious implantation technique Degradation to acidic products No resterilization Inflammatory reactions Sterile sinus formation Induced osteolysis
Silk	Ease of implantation Resterilization Degradable device Flexibility for growing bones (hydrated mechanicals) Can be coated with bioactive compounds	Silk material may degrade too slowly Hydrated mechanicals may render them too weak

Abbreviations: PGA, polyglycolic acid; PLA, polylactic acid; PLGA, polylactic coglycolic acid.