Advancements in Bone Fixation Utilizing Novel Biointegrative Fixation Technology

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KEYWORDS

• Bone • Fixation • Orthopedics • Absorbable • Biocomposite • Biointegrative
• Reinforced • Polymer

KEY POINTS

- Advancement in orthopedics has been increasing rapidly.
- With time, metallic hardware will begin to be replaced by novel materials that become one with the body.
- This progress will not only aid in the repair process it will allow permanent and improved reinforcement of the fixated region.
- Biointegrative technology is a promising new generation of materials capable of achieving this goal.
- It is expected that plates, screws, pins, interference screws, and even possibly joint replacements will incorporate into the patients' bodies, negating the need for hardware removal and adding structure and stability to an iatrogenically weakened area.

INTRODUCTION

Fixation of fractures and osteotomies has progressed dramatically with the advent of internal fixation. Before internal fixation, most fractures were placed in casts and anatomic fixation was difficult to achieve. In the mid-1950s, screw fixation was introduced by the AO Foundation with carpentry techniques used to fixate bone. Over the course of 60 years, fixation has been advanced to include cannulated systems, headless systems, different plate/screw combinations, and some absorbable or allograft

Disclosure: Dr B. Baravarian is an investor in Ossio, head of the foot and ankle advisory board, and a consultant to the company.

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Clin Podiatr Med Surg ■ (2017) ■–■
http://dx.doi.org/10.1016/j.cpm.2017.08.009 podiatric.theclinics.com
0891-8422/17/

bone fixation options. However, there has been little advancement that has dramatically and significantly changed fixation techniques from a biomaterial standpoint, with the main material used still being nonabsorbable steel or titanium.

Metal, in any form, is an excellent fixation material. However, metal has downsides. On a positive note, metal is inert and does not cause much reaction as long as the patient does not have a metal allergy. Second, it offers a solid fixation that is stronger than bone and adds significant strength to a fracture or osteotomy fixation.

On the negative side, metal screws may need to be removed and the AO Foundation recommends removal of hardware, which requires a second surgery. Metal also is not good for imaging and often gives off significant signal with both MRI and computed tomography imaging. In addition, hardware removal may be difficult, with screw stripping and breakage, and can leave the bone hollow in the region of hardware removal, resulting in bone weakness.

Absorbable hardware has been attempted several times in orthopedic fixation. Most of the material previously used was made out of suture material stranded together. The problem with absorbable material has been that the absorption usually occurs all at once with what is called a burst effect, which means that the material degrades significantly and all at once through an acidic process causing cystic changes and leaving the bone exposed to weakness in the region of absorption. Furthermore, the region of absorption has, at times, formed cystic changes that can be painful and grow with time within the bone. In addition, there has been no absorbable material, other than bone, that has offered support and adjustable strength. Such a material would be ideal because it would allow the transfer of strength to the bone slowly while the material is replaced by new bone formation for added strength and stability.

Bone allograft has become popular in foot and ankle fixation. The bone is milled into the shape of pins and plugs that are press fitted into the bone. This technique offers superior benefits to previous absorbable materials because bone can grow into the allograft and allow additional stability; bone allograft rarely needs to be removed; can be cut through, which allows ease of secondary surgery options; and is fairly inert. However, bone allografts have sterility and infection risks. The bone materials also differ in strength depending on the quality of the allograft material, which may differ from person to person. Bone pins or screws also cannot be modified for surgical location–specific strength and absorption options. In addition, the bone material can be brittle during insertion, resulting in fracture or stripping of the hardware during insertion. This risk means that the bone is mainly used as a plug or pin and cannot offer rigid fixation or compression.

THE IDEAL BONE FIXATION MATERIAL

In an ideal situation, fixation of bone should offer multiple benefits and reduce multiple current negative factors. The benefits include:

1. Strength comparable with or greater than the bone that is being fixated, with slow decrease in strength to allow the bone to increase its strength.
2. Absorption of the material in a timely and quiescent manner without burst effect.
3. Replacement of the fixation material with bone to allow for strength, and negate the risk of cysts or hollow bone regions in a slow and sustained manner.
4. Ability to achieve rigid fixation and compression from the material, with multiple forms of fixation being possible in the form of screws, plates, pins, and rods.
5. No need for removal of the material.

If all of these qualities were to be met, absorbable fixation would be superior to nonabsorbable fixation because there would be all the benefits of metal fixation