



Repairing Fractured Bones by Use of Bioabsorbable Composites

Less surgery would be necessary, and full strength would be restored sooner.

Langley Research Center, Hampton, Virginia

A proposed method of surgical repair of fractured bones would incorporate recent and future advances in the art of composite materials. The composite materials used in this method would be biocompatible and at least partly bioabsorbable: that is, during the healing process following

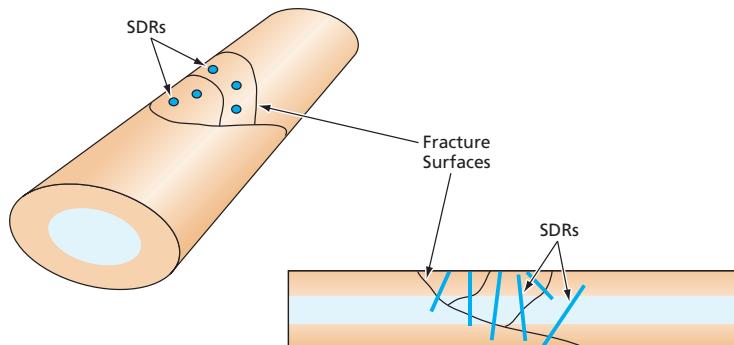
surgery, they would be wholly or at least partly absorbed into the bones and other tissues in which they were implanted. Relative to the traditional method, the proposed method would involve less surgery, pose less of a risk of infection, provide for better transfer of loads across fracture sites,

and thereby promote better healing while reducing the need for immobilization by casts and other external devices.

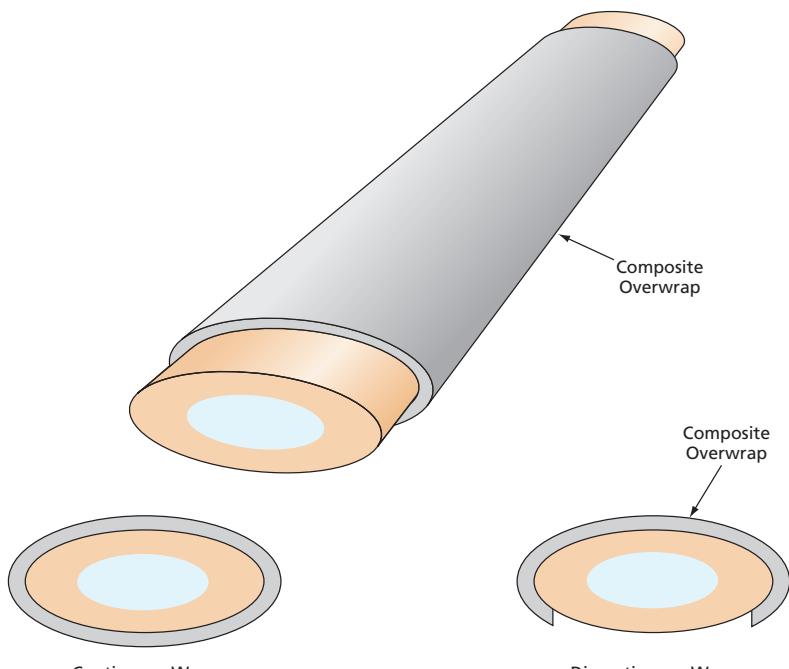
One requirement that both the traditional and proposed methods must satisfy is to fix the multiple segments of a broken bone in the correct relative positions. Mechanical fixing techniques used in the traditional method include the use of plates spanning the fracture site and secured to the bone by screws, serving of wire along the bone across the fracture site, insertion of metallic intramedullary rods through the hollow portion of the fractured bone, and/or inserting transverse rods through the bone, muscle, and skin to stabilize the fractured members. After the bone heals, a second surgical operation is needed to remove the mechanical fixture(s). In the proposed method, there would be no need for a second surgical operation.

The proposed method is based partly on the observation that in the fabrication of a structural member, it is generally more efficient and reliable to use multiple small fasteners to transfer load across a joint than to use a single or smaller number of larger fasteners, provided that the stress fields of neighboring small fasteners do not overlap or interact. Also, multiple smaller fasteners are more reliable than are larger and fewer fasteners. However, there is a trade-off between structural efficiency and the cost of insertion time and materials.

The proposed method is further based partly on the conjecture that through-the-thickness reinforcements could be excellent for fixing bone segments for surgical repair. The through-the-thickness reinforcements would superficially resemble nails in both form and function. Denoted small-diameter rods (SDRs) to distinguish them from other narrow rods, these reinforcements would be shot or otherwise inserted through adjacent segments of fractured bone to fix them in their correct relative positions (see figure). Shot insertion would be effected by use of an applicator that would amount to a miniaturized and highly refined version of the pneumatic guns often used in carpentry to drive nails and brads. The applicator, envisioned to be about the size of a ball-point pen, would be



BONE WITH COMPOUND FRACTURE,
FIXED BY USE OF SDRs



BONE WITH COMPOSITE OVERWRAP AFTER
FIXING WITH USE OF SDRs

SDRs Would Be Driven Like Nails through adjacent segments of a fractured bone. By use of two or more SDRs oriented at different angles, the segments would become locked together. The fractured bone would be further immobilized by an overwrapped composite-material shell.

driven by pressurized carbon dioxide. To further promote stabilization of the segments, layers of bone glue could be applied to the fracture surfaces prior to insertion of the SDRs. The bone glue could be therapeutically loaded with chemicals to promote growth of bone and fight infection.

SDRs would be produced in a variety of diameters to suit specific applications. Typical diameters are expected to range from 0.02 to 0.1 in. (about 0.5 to 2.5 mm). An SDR could be fabricated as a matrix/fiber composite material: The fibers could be made of a biocompatible glass or polymer, and the matrix would be made of a bioabsorbable material that could be therapeutically loaded with bone-growth and infection-fighting chemicals. Optionally, the fibers could be made of a bioabsorbable

material, so that in time, nothing of the SDR would remain in the healed bone. Yet another option would be to fabricate an SDR as a metal tube containing bone-growth and infection-fighting chemicals that would leach out through pores.

Once the bone segments were fixed in place by insertion of SDRs, additional structural support and immobilization would be provided by wrapping and co-curing a multilayer composite-material shell around the outer surface of the fractured bone. This shell would be made of a fabric preimpregnated with a curable, bioabsorbable matrix resin. From a purely structural perspective, it would be preferable to form the shell around the entire circumference of the bone; from a surgical perspective, it could be more practical

to form the shell part way around the circumference and strengthen the bone by use additional SDRs.

The curing of the composite would create a rigid structural element integrally bonded to the bone. The combination of the SDRs and the composite shell may be sufficient to restore the bone to its original strength, or nearly so. Hence, there would be little or no need for a cast or other external immobilizing device. At the least, the amount of time the patient must wait before returning to normal activity should be less than it would be if the repair were performed by the traditional method.

This work was done by Gary L. Farley of the U.S. Army Research Laboratory for Langley Research Center. Further information is contained in a TSP (see page 1). LAR-16354-1