Proximal Humeral Fractures: Management of Failed Fixation

Donald A. Wiss, MD

Proximal humeral fractures represent approximately five percent of all fractures seen in clinical practice. The vast majority occur in the elderly, with 75 percent occurring in patients greater than 65 years of age, with a strong female predominance. In patients greater than 65 years of age, proximal humeral fractures are the third most common fracture after hip and wrist fractures.

Displaced proximal humeral fractures are complex injuries and difficult to treat. They often alter shoulder kinematics, leading to functional impairment and loss of shoulder motion. With the introduction of locking plates, internal fixation of these fractures has become more common. While restoration of shoulder anatomy correlates closely with function, the use of these implants are not without complications.

Traditionally, proximal humeral fractures have been difficult to manage because of fracture comminution, compromised bone stock, imperfect implants and unpredictable outcomes. As a consequence of injury, many patients are left with shoulder pain, limb weakness, stiffness, loss of function and, in some cases, arthritis. The main challenge in treating difficult proximal humeral fractures is not fracture union, but recovery of shoulder motion.

For proximal humeral fractures, several key principals of management are widely accepted:
1. More than 70 percent of these injuries can be treated without surgery.
2. For displaced and unstable fractures, internal fixation or arthroplasty improves results.
3. Poor results following primary treatment of a displaced proximal humeral fracture is very difficult to reconstruct later, adding increased significance to the initial treatment.

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4. While surgery offers the patient the best chance for a successful outcome, the worst complications come from unsuccessful surgery.

Case study

A 53-year-old school teacher fell off a step-stool, sustaining a proximal humeral fracture (Fig. 1). She was treated at an outside facility by open reduction and internal fixation of her fracture (Fig. 2). Nine months following the injury and surgery, the fixation failed and the patient had a painful, stiff shoulder. She was then seen by a second orthopaedic surgeon who revised her fixation, which also failed (Fig. 3).

Sixteen months after her injury, the patient was referred to Cedars-Sinai Medical Center for treatment of an established non-union and fixation failure. The patient was managed by revision internal fixation with a long periarticular locking plate, iliac crest bone graft, and OP-1 bone morphogenetic protein (Fig 4). Over the course of the next 12 months, the fracture healed and the patient was able to resume her job as a schoolteacher and her hobby of gardening (Fig. 5).

**Figure 4A-B**: Revision internal fixation with a long periarticular locking plate, iliac crest bone graft and OP-1 bone morphogenetic protein.

**Figure 5A-B**: Healed fracture after 12 months.

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**Novel Techniques for Spinal Deformity**

**Michael A. Kropf, MD**

Adult spinal deformity (scoliosis and kyphosis) of the thoracolumbar spine is particularly challenging for the spinal surgeon. Patients typically present with progressive spinal curvature, truncal imbalance, moderate to severe pain due to neurologic impairment and degenerative disc disease.

Similar to all chronic painful spinal disorders, non-operative care includes exercise, education, non-steroidal anti-inflammatory drugs and interventional pain management with epidural injections and facet joint blocks. The decision for surgical treatment is appropriate when activities of daily living are severely impacted by pain and dysfunction.

Correction of spinal deformity has been greatly improved with major technological and implant innovations that have allowed greater control, correction, prevention of pseudoarthrosis and ease of early rehabilitation. Segmental fixation over many fusion levels is combined with neurologic decompression, anterior thoracolumbar release, posterior osteotomies and partial or complete vertebrectomies. However, complicated curves have significant risks that include neurologic injury, infection, postoperative medical complications, late nonunion and need for reoperation.

New devices and biologic implants such as bone morphogenetic protein (BMP) and minimally invasive lateral approaches to the thoracolumbar spine – extreme lateral interbody fusion (XLIF) or direct lateral interbody fusion (DLIF) – have allowed better correction and increased fusion rates. Posterior implantation via percutaneous techniques may allow correction without the morbidity of muscle dissection and scarring.

**Case example**

A 44-year-old male, working as a flight attendant for a major airline, was referred for evaluation of disabling back pain and upper lumbar kyphosis. Imaging tests revealed a 30° upper lumbar kyphosis with severe degenerative disc disease L1 to L4. After five years of conservative care, including therapy, medications and pain management, he was forced to go on disability and had lost all ability to perform recreational activities.

Preoperative studies, MRI and CT-discogram were used to determine proximal and distal levels for fusion. Unfortunately, L4-L5 and L5-S1 discs demonstrated grade III degeneration,

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Parathyroid Hormone and Structural Bone Allograft

Dan Gazit, DMD, PhD

While bone tissues have regenerative capabilities that enable self-repair of fractures, in extreme situations in which the extent of bone loss or damage due to trauma, surgery, or a metabolic disease such as osteoporosis is too large, complete regeneration will not occur. In these circumstances the extent of the bone loss is beyond the capabilities of the bone self-repair mechanism and a bone graft implantation is needed.

Bone grafting is commonly used in orthopaedic reconstruction surgeries such as spinal fusion, revision of failed total hip arthroplasty, or repair of skeletal defects following the removal of tumor or trauma. Approximately 1.6 million bone grafts are performed each year to regenerate bone lost due to trauma or disease, of which six percent are cranio-maxillofacial in nature. These grafts could be generated from live (autograft) or dead (allograft) bones. Autograft has the ability to stimulate new bone formation by recruitment of mesenchymal stem cells (MSC) from the host bed (osteocductive), and can also regenerate itself by production of new bone (ostegenesis). Unfortunately, autologous bone, which is usually used to treat these lesions, is not always available and its harvest requires the mutilation of another bone. In contrast, a processed allograft can only function as an osteoconductive scaffold and has no osteogenic properties. Thus allograft healing is passive and relies upon invasion by host cells and tissues. This limited bone forming and remodeling is directly associated with the foreign body-reaction and has no osteogenic properties. Thus allograft healing is passive and relies upon invasion by host cells and tissues. This limited bone forming and remodeling is directly associated with the foreign body-reaction and has no osteogenic properties. Thus allograft healing is passive and relies upon invasion by host cells and tissues. This limited bone forming and remodeling is directly associated with the foreign body-reaction.

Bone grafted portions of parathyroid hormone, for use as an anabolic agent in the treatment of severe osteoporosis. Initial human studies with teriparatide have demonstrated both its safety, and also the capacity to increase cancellous bone volume, increase cancellous bone connectivity, and increase cortical thickness in the iliac crest. Treatment of osteoporotic patients with teriparatide increases bone mass 10 to 15 percent per year, decreases the incidence of back pain and decreases the risk of new vertebral fracture by two-thirds (notes 4-6). Intermittent PTH administration is also well known to have anabolic effects on craniofacial bones (note 7).

In a recently awarded National Institute of Dental and Craniofacial Research (NIDCR) RO1 grant, we intend to investigate the effect of systemic PTH administration on fracture healing using structural allografts. Specifically, we will utilize a calvaria allograft model in transgenic mice, which emit visible light when active bone formation occurs (note 8; Figure 1). It is anticipated that PTH will increase the osteointegration of the calvaria allograft and prevent scar formation, an unwanted event that is often associated with allograft bone healing. The results of this study are designed to provide the preclinical efficacy data to support a clinical trial of PTH therapy in adult trauma patients. Thus, this program also has potential for immediate translation and significant impact on maxillofacial and orthopaedic surgery.

Dr. Gazit is Director of the Stem Cell Therapeutics Research Laboratory and the Molecular and Micro Imaging Core at Cedars-Sinai. This research is conducted in partnership with Edward M. Schwarz, PhD of the Center for Musculoskeletal Research, University of Rochester Medical Center, and key personnel include Zulma Gazit, PhD, Wafa Tawackol, PhD and Gadi Pelled, PhD from the Stem Cell Therapeutics Research Laboratory at Cedars-Sinai.

References
7. Dan Gazit, DMD, PhD

Figure 1: A 5-mm diameter defect is created in the calvaria bone (micro CT image - A). A disc-shaped allograft in the same size is prepared from a donor mouse (B). Allograft is implanted in the calvaria defect of the recipient transgenic mouse (micro CT image - C). Bone formation activity is noninvasively monitored using a highly sensitive camera detecting light emitted from the allograft implantation site (D). The transgenic mouse harbors a Luciferase gene, which is activated when bone formation is occurring.

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Case Study: Amputation vs. Limb Salvage

Earl Warren Brien, MD

The decision between amputation and limb salvage is often a difficult one and can only be made after a thorough individual patient evaluation. Several factors require consideration, such as the extent and severity of vascular injury, bone and soft tissue destruction, the type and duration of limb ischemia, and the patient’s age and previous health status. When limb salvage is chosen, efforts should be directed not just to salvaging the limb, but to producing a functional, painless extremity.

A 53-year-old female who had previously undergone four total knee arthroplasties was informed by her physician that amputation was her next and only option due to the significant bone destruction of the femur and tibia. The patient came to Cedars-Sinai Medical Center for a second opinion. Several options were discussed, including amputation, but the patient opted to try a limb salvage procedure.

Although the case presented was a complex multiple revision, it was treated like a tumor case, where half the femur and half the tibia were resected and then reconstructed. During the long, technically demanding surgery, 35 cm of metal was used to reconstruct from the middle femur to the middle tibia.

The outcome was excellent. Postoperatively, the patient is able to walk without pain and says that she hasn’t felt this good since her first surgery many years ago.

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Dr. Kropf is a board-certified orthopaedic surgeon at the Cedars-Sinai Spine Center. He specializes in the treatment of cervical and lumbar disease, disc arthroplasty, scoliosis, deformity and complex spinal reconstruction.

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Annular tears and concordant pain on injection. Thoracolumbar fusion was performed in a two-stage procedure. Anterior fusion with XLIF and BMP from T12-L4 combined with posterior instrumentation T11 to L4 allowed correction of the kyphosis and improved sagittal balance. Lumbar disc levels L4-L5 and L5-S1 were treated with artificial disc replacement to avoid fusion to the pelvis.

Now, at one year post-op, the patient is radiographically healed and performing all activities of daily living and recreational sports with little or no pain.

Alternatives in deformity surgery have allowed less invasive approaches, and avoidance of the morbidity related to anterior surgery and use of autologous bone harvesting.

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