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Xray 150
Common Surgical Hardware
Used and Seen on Plain Film Radiographs

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Being bone and joint specialists, chiropractors will be receiving patients who have had orthopedic surgery or will be referring patients to get orthopedic surgery. As a result, looking at orthopedic hardware on x-rays will be a daily occurrence. It behooves the chiropractor to be aware of what orthopedic hardware the patient has received and why, and to be able to explain orthopedic hardware insertion procedures in patients being referred for these surgeries. This course will focus on the spine, hip, and shoulder – the three most common chiropractic regions of treatment with a brief presentation of other extremity fracture repairs and possible complications.
Section I – Hip fracture orthopedic hardware

**General information**

Bone quality is a term used to describe the “aspects of bone that affect its ability to resist fracture” and they include bone structure such as geometry and microarchitecture as well as material such as mineral and collagen composition. Hip fractures are most commonly due to poor bone quality known as fragility.
and thus are responsible for great morbidity and mortality, especially in the elderly where fragility is more likely to occur. By the year 2040, 500,000 hip fractures are estimated to occur in the United States alone with an estimated annual healthcare cost of over $9.8 billion. Because most elderly patients will have comorbid issues, one would predict that non-operative methods would be preferred; however, non-operative management has fared poorly in the literature. Non-operative treatment has been shown to increase hospitalization, create more mal-union, and result in a less independent level of functioning. These consequences can result in urinary complications or pulmonary complications, such as the dreaded pneumonia, because pain prevents the patient from being able to void properly and to cough. Therefore, the goal for hip fractures is to achieve a stable, painless extremity in the quickest time possible.

Early surgery has been shown to reduce the duration of pain and dependency, and those that delayed surgery had a worse rehabilitation than those who had an early surgery. Early surgery also decreased the number of bed sores that result from damage of the skin due to prolonged immobilization. Post-operative hospitalization was reduced in those with a short pre-operative waiting time. The literature is conflicting about whether delaying surgery has any impact on mortality however. Bottle, et al. suggested that surgery must be done within the first twenty-four hours of fracture. McGuire, et al. found a higher risk of mortality within thirty days in patients whose surgery was delayed two or more days. On the other hand, Lefaivre, et al. did not find a delay in surgery to affect short-term mortality. Thus, erring on the side of caution, the earlier the surgery can safely be performed, the better for the patient.

Key points:

- Hip fractures are common and are becoming more common as the elderly population continues to increase
- Surgery is typically preferred over non-operative approaches to reduce complications
- The time of surgery is still yet to be determined

Surgical options

Now that surgery has been determined to be the best course of action, what surgical approach to femoral neck fractures is best? The choice is between arthroplasty and internal fixation.
Figure 1b. Hip arthroplasty
In the arthroplasty category, is total hip arthroplasty best or hemi-arthroplasty? In the internal fixation category, the choice is between multiple screws and sliding hip screw fixation. Figure 1b and c above show the difference between arthroplasty and internal fixation respectively. There are pros and cons to each type of fracture treatment. Those surgeons who prefer arthroplasty state that there is better postoperative function and lower rates of revision surgery. Revision is less likely because replacing the femur head eliminates the risk of nonunion or avascular necrosis of that head. When comparing the two forms of arthroplasty, the hemi-arthroplasty is an easier and less time consuming surgery, has a lower risk of dislocation, and is a cheaper surgical procedure compared to the total hip arthroplasty. The down side to the hemiarthroplasty is the effect on the acetabulum. There is rapid wear of the acetabular articular cartilage and greater pain is reported. Those that prefer the total hip replacement cite the better function and the lower risk of failure as compared to both the hemiarthroplasty and the internal fixation approach. Lastly, those that prefer internal fixation claim that the shorter operative time, less blood loss, less risk of dislocation and less risk of postoperative wound infection make internal fixation preferable over arthroplasty. The choice is not as easy as surgeon preference as certain fracture situations would cause one approach to be more appropriate than another. For example, nondisplaced fractures are appropriately treated with the sliding hip screw. Peritrochanteric hip fractures are best treated with a sliding hip screw while subtrochanteric fractures need multiple screws. In patients with displaced femoral neck fractures and those with poorer bone quality would benefit more from joint arthroplasty because a reoperation rate of forty percent has been noted when a sliding hip screw is attempted in this population. The hemiarthroplasty is more appropriate for older less mobile patients.
while total hip replacement is better for younger and more active patients. More than 1 million total hip replacements are performed each year with the expectation that this number will double during the next 20 years. Even after the choice of surgery is made, there is even more controversy. With arthroplasty, should cemented stems or press-fit stems be used? Cemented femur stems are higher risk for fat embolism and revision is difficult. Uncemented arthroplasty has a longer recovery time, higher cost, and more incidences of thigh pain. There is no clear answer. No matter the treatment utilized, the goal of the hardware should be to provide more load bearing rather than load sharing since most of these fractures occur in osteoporosis patients. The orthopedic hardware should allow for early weightbearing and mobilization because long periods of immobility greatly increase the morbidity in these patients.

Key points:
- Surgical options include arthroplasty or internal fixation
- Arthroplasty options are hemi-arthroplasty or total hip replacement
- Internal fixation options are sliding hip screw fixation or multiple screw fixation

**Ancillary considerations**

Yes, the patient will need surgery to fix the fracture; however, investigate why the patient fractured in the first place. Most hip fractures are fragility fractures. Thus between seventy and ninety percent of patients with hip fractures have insufficient levels of Vitamin D (serum 25-hydroxy-vitamin D levels below 32 ng/mL). The National Health and Nutrition Examination Survey III study showed that there was improved gait speed and “performance on lower extremity function tests in women older than sixty years with increasing levels of 25-hydroxy-vitamin D up to 40ng/mL”. Fall risk was also reduced by nineteen percent with vitamin D supplementation. Patients were given 700 IU vitamin D3 daily. Vitamin D comes in two forms: ergocalciferol (vitamin D2) which is derived from plant and yeast sources, and cholecalciferol (vitamin D3) which comes from animal sources. Bukata et al. recommended giving ergocalciferol initially postfracture over eight weeks because large doses can be given to raise the vitamin D levels quickly. After appropriate levels are obtained, the patient can be switched to 2000IU cholecalciferol for their daily supplement thereafter.

This nutritional change is an important component to future fracture prevention but is typically overlooked; therefore, do not assume that other managing physicians will have addressed this need with the patient. The importance is truly VITAL. Mortality after hip fractures has changed very little over the past forty years despite substantial medical advances. As of the year 2000, only sixteen percent of patients with fragility fractures of the hip received therapy for osteoporosis. By 2010, the number had changed very little with only twenty percent receiving osteoporosis therapy. Thus, each patient deserves an assessment of bone quality, such as through a dual-energy xray absorptiometry scan, determination of the reason for the fragility from basic laboratory values, and recommendations of taking calcium and vitamin D supplements.
Key points:

- Patients with fragility fractures need treatment for the poor bone quality

References


Section II– Shoulder Replacement Orthopedic Hardware

The featured patient in this section is a patient who had osteoarthritis of the glenohumeral joint that made mobility difficult and painful. Shoulder replacement was chosen for this patient, which is common since primary glenohumeral osteoarthritis is the number one reason for shoulder replacement.

Figure 2a Show’s the glenohumeral osteoarthritis and Figure 2b shows the same patient after the shoulder joint replacement.
Figure 2a shows the classic signs of osteoarthritis. The patient has decreased joint space, subchondral sclerosis and an inferior bone spur. Figure 2b shows a shoulder replacement. To perform a shoulder replacement, adequate glenoid bone stock must be present in order to assure solid fixation of the glenoid component. As you can see in the figure, the diaphysis must be sufficient to receive and hold the metal shaft of the replacement. Total shoulder replacement (TSR) is used primarily for osteoarthritis, post-traumatic arthritis, and occasionally, inflammatory arthropathies, like rheumatoid arthritis. Another required feature to obtain a successful TSR is good function of the rotator cuff. The rotator cuff consists of supraspinatus, infraspinatus, subscapularis and teres minor. These four muscles work with the deltoid muscle to move the shoulder, especially in abducting the arm for patient function. The negative of TSR is the fear of loosening of the orthopedic hardware, and thus, most TSR surgeries are performed on older, less physically demanding individuals. While the number of older patients with more medical co-morbidities (like congestive heart failure and diabetes) are undergoing total joint replacement, mortality rates are decreasing while post operative complications are increasing. The orthopedic hardware is well seeded in Figure 1b. Loosening would be evident when a black line is seen around the metal, indicating the area of movement of the orthopedic hardware.

Other types of shoulder replacement surgeries

There are two other common shoulder replacements besides the one shown here. Another option is the hemiarthroplasty. These are surface replacements called resurfacings and stemmed prostheses. The hemiarthroplasty looks like a thumb tack with a metal humeral head and a tiny stalk that sticks into the humeral neck. This orthopedic hardware option is used for focal arthritis, cartilage damage to the humeral head, and avascular necrosis where there is still adequate supporting bone. This is not a good option for inflammatory arthritis because the condition results in soft bone that would cause a high risk of glenoid erosion. TSR is better for these patients. The advantage of the hemiarthroplasty (HAS) is that it preserves bone stock by being smaller but still restores the normal anatomy contour.

The last option is the reverse shoulder replacement (RSR) which is exactly as the name suggests. The socket is on the humeral side and the ball component is on the scapula side. This option is best for a failed TSR where a glenoid reconstruction with bone graft would have been required. Other indications include: proximal humeral malunion and non-union, acute fracture, and revision surgery for failed HAS. The RSR increases the tension on the deltoid muscle so a functional deltoid is required but it decreases the mechanical torque on the glenoid thus reducing the risk of loosening.

Assignment: When discussing a surgical referral for your patient, what surgical option is best for the different types of shoulder pathology?

History of the shoulder replacement

While the RSR was not designed until the 1980s, shoulder replacement began in Paris back in 1893 by surgeon Jules-Emile Pean. The shoulder replacement preceded the hip replacement by more than 25 years. The implant was made of rubber and platinum and maintained functional integrity for two years. The second shoulder replacement was made of ivory in 1914 but further shoulder replacements were not attempted until 1951 when a resin prosthesis was produced. The main problem was loosening and
thus was not highly utilized. Shoulder replacements have really started to evolve in the 1980s as the replacements tried to mimic the normal architecture of the shoulder. Not all people are designed identically; therefore, a cookie-cutter prosthesis is not going to be adequate. Currently, the fourth generation of shoulder replacements are utilized which consists of variable head positions in three axes, making for an adaptable shoulder arthroplasty.

The future of shoulder replacement surgery has been focusing on pyrolytic carbon as a bearing surface for humeral head replacement. This material articulates well with native glenoid tissue.

**Preparing the patient for the surgical experience**

The shoulder is made of the scapula, humerus, and clavicle with two synovial joints. These joints consist of the glenohumeral joint and the acromioclavicular joint. The ball shaped humerus head articulates with the socket shaped glenoid cavity of the scapula. This is the most mobile joint in the body which makes it great for movement but weak for stability and thus is easily injured. Just like with people, the more freedom someone has the more risk there is for getting into trouble. When trouble arises, sometimes surgery is needed.

Initially, the patient will receive a three view shoulder x-ray series, consisting of a glenohumeral anterior posterior view, a scapula outlet view, and an axillary lateral view. From the radiographs, the proper stem size can be ascertained. Currently, the prosthesis is likely to be vitallium which is an inert metal and is superior to non-metallic material. At the time of surgery, the patient is in the barber-chair position with the head and knees being raised thirty degrees. An incision is made beginning at the clavicle and passing downward 12.5cm over the deltopectoral interval. This location preserves the strength of the deltoid. The deltoid is reflected, the arm is placed in full external rotation, and the capsule is opened transversely. The biceps tendon is moved and the center of the medullary cavity is located. Holes are made and the prosthesis is set. The humeral head must be in the normal 20 degrees of retroversion or anterior subluxation is likely. Following surgery, the arm is placed in a sling and swath. Pendulum exercises can begin after forty-eight hours and wall climbing exercises can begin as tolerated. The arm is allowed freedom on the fourth day but is bound at night for three weeks. After one week, aquatic therapy to increase mobility can begin. Not until the third week is external rotation or abduction allowed due to the healing of the subscapularis. This timeline is extended to six weeks if the cause of replacement was due to an inflammatory arthropathy.

**Potential surgical complications**

During the surgery, humeral injury must be avoided such as diaphyseal or tuberosity fractures. Glenoid fractures can occur during reaming, rotator cuff injury and neurovascular complications need to be avoided. As with all surgeries, bleeding can be an issue.

After surgery, infection, aseptic prosthetic failure, prosthetic instability, secondary rotator cuff failure, and postoperative stiffness may ensue. In acute fracture cases, nonunion or malunion are also a concern. Acromial stress fractures are possible following RSR. Lastly, avoiding the need for revision surgeries is best. Currently, the revision surgery success rates are less than twenty percent.
Key points:

- The three shoulder replacement surgeries commonly utilized are the total shoulder replacement, hemiarthroplasty, and reverse shoulder replacement.
- The shoulder replacement began in 1893 but while having a long history, the rapid use and innovation of the surgery really only began in the 1980s.
- The surgery seeks to maintain good deltoid and rotator cuff function while reducing the risk of complications: vascular, neurological, osseous, articular, and muscular.
- Fractures, dislocations, malunion, and revision surgery are all potential surgical complications.

References

Section III – Spine pedicle Screw fixation

History of the Pedicle Screw Fixation

The featured patient in this section has a three level upper lumbar pedicle screw fixation. Pedicle screws can be made of either stainless-steel or titanium. The original pedicle screw instrumentation began with King in the 1940s but his form of spinal fixation had a high incidence of failure and often resulted in pseudoarthrodesis, an unstable fusion. This choice of orthopedic hardware for lumbar spine fixation became energized in the early 1960s with the work of Roy-Camille and colleagues in Europe. In addition to the screws introduced by King, Roy-Camille’s group connected the implanted screws with a plate. Most individuals who work with patients suffering from scoliosis have heard of the Harrington rod to treat scoliosis. Harrington’s original work with scoliosis, published in 1969, featured pedicle screws inserted into L4 and fastened to rods. By 1977, Mageri introduced the percutaneous pedicle screw which was minimally invasive compared to previous. A small incision was made to implant the screws and insert the rods. The advantages of this advance meant less muscle dissection, less postoperative pain, less blood loss, shorter hospital stays and shorter rehabilitation but it came at the cost of no direct visualization for the surgeon. Thus, breaches in the pedicle during surgery ranged from six to ten percent. In 1985, Ashman used a screw-plate fixation designed by Luque in conjunction with Danek Medical in tests on subjects at the Texas Scottish Rite Hospital for Children. This work resulted in the first FDA approved DANEK Plate and Screw. Currently, there are over fifty vendors that have pedicle screw hardware for sale.
While popular with medicine, this hardware has struggled in the public opinion polls. In 1993, the television show 20/20 reported the use of “off-label” bone screws for lumbar spine fixation. A firestorm of liability lawsuits ensued against almost all US manufacturers of orthopedic screws. The DANEK group fought back against these lawsuits and was ultimately victorious. On February 2001, the US Supreme Court ruled with the following statement, “off-label usage of medical devices for some other purpose than that for which it has been approved by the FDA is an accepted and necessary corollary of the FDA’s mission to regulate in this area without directly interfering with the practice of medicine.” The FDA had originally limited the use of pedicle screws to severe L5/S1 spondylolisthesis. With this court ruling, the pedicle screw has since profoundly influenced the practice of medicine well beyond the scope of L5/S1.

Key Points:

- Roy-Camille and colleagues started the great influence that the screw-plate fixation would have on orthopedic stabilization of the spine.
- The US Supreme Court helped to expand the screw-plate fixation beyond its originally approved use on L5/S1

Uses for Transpedicular Instrumentation

While the pedicle screw was used to stabilize L5/S1 spondylolisthesis and was used by Harrington in the treatment of scoliosis, the pedicle screw has much broader usage today. Transpedicular instrumentation has been used to treat degenerative changes in the spine, traumatic insult stabilization, pathologies involving tumors, and many spinal deformities. In many conditions, pedicle screws have become the orthopedic hardware of choice. The advantage has been the better spinal fusion rates, enhanced rigidity and stability of the spine, correction of more aggressive spinal deformities and often, fewer neurological risks. The current hardware has multi-dimensional spinal fixation that helps the surgeon meet the individual anatomy needs. Currently, approximately 158,000 individuals receive lumbosacral spinal surgeries using pedicle screws annually. Pedicle screws have even become popular in the cervical and thoracic regions, increasing the number of annual US cases of pedicle screw usage in surgery to approximately 187,0000 cases/year.

Key Point:

- Pedicle screws are currently used to treat degenerative spine changes, trauma stabilization, and spinal deformities

Surgical Procedure Concerns and Potential Remedies

With the use of percutaneous placement of pedicle screws, the surgeon is no longer able to directly visualize the pedicle. Misplacement is the surgeon’s greatest fear.

When using the thoracic pedicle screws, the concern is medial penetration leading to spinal cord injury. Thus, you might say to err on the side of caution, and go with a more lateral placement. Unfortunately, lateral penetration can result in major vessel insult, such as the aorta or spinal segmentals or vessels going to the viscera. The highest risk is screws in the scoliotic concavity when significant rotation is
evident. You can imagine the difficulty of placement with this major anatomical distortion. Besides these complex cases, the thoracic pedicle is more difficult to work with because of its small size compared to lumbar and its variability in diameter, shape, and angle.

For lumbar spine, the lumbosacral nerve root is close to the medial and inferior wall of the pedicle. Approximately twenty-one percent of cases had cortical perforation of the pedicle and iatrogenic injury of spinal nerve roots ranged from one to eleven percent. While this percentage appears low, it is significant that the doctor caused injury in one out of every ten patients.

In the cervical spine, a posterior surgical approach may result in significant myofascial pain due to musculature stripping during surgery. The posterior approach is preferred due to the superior stabilization capabilities. The anterior approach is less traumatic and prevents damage to the paravertebral muscles but because it is anchored in cancellous bone, stability is less and likelihood of failure is increased. Plus, there are few landmarks on the anterior surface of the cervical vertebra and the distance from the anterior surface to the pedicle is relatively long. This makes pedicle screw insertion more difficult and dangerous. Breaching the pedicle in the cervical spine may result in vertebral artery damage laterally or nerve root and thecal sac damage when medial.

Thus, intraoperative techniques must be employed to determine adequate placement. Diagnostic imaging is one choice. Biplanar radiography, computer-assisted/stereotaxic imaging, and computed tomography (CT) can be utilized but lack a reliable three dimensional assessment and have had an accuracy rate of only eighty-three percent at best. Fluoroscopy-guided pedicle screw insertion resulted in a 78.3 percent correctly placed screw rate. A better technique has been needed and thus, current research is being done on pedicle screw stimulation techniques.

In 1991, Rosen first described a nerve stimulator technique applied to an implanted pedicle screw and he observed the rhythmic twitching of leg muscles synchronous with the stimulation rate. This response indicated that the screw was touching the nerve root. When the screw was repositioned, the nerve stimulator did not cause the response and thus, he concluded that the nerve stimulator can determine adequate pedicle screw placement. While valuable, the technique was criticized for being an “after the fact” technique. Since then, other stimulation techniques have been devised. One such technique is looking at the differences in the electrical impedance of biological tissues as a “real time monitor for detecting pedicle screw perforation.” There is currently a wireless, electronic, hand held instrument that measures electrical conductivity of the tissues for determining proper formation of the hole, prior to screw implantation. This early research is showing a ten percent reduction in time for the surgeon and requires fewer fluoroscopic images, reducing patient radiation exposure by about thirty percent. This technique also prevents the complications that would ensue had the screw been implanted in an improperly placed hole. While the field of stimulator technique as a means of proper pedicle screw placement is under rapid development, currently, this technique is a practice option but not a gold standard. More research will determine the fate of these monitoring techniques.
Key Points:

- Complications of a misplaced screw can result in neurological or vascular compromise
- Placement of pedicle screws can be monitored via diagnostic imaging and/or stimulator techniques

Figure 3b,c. Figure b. Shows a pedicle fracture post motor vehicle accident. The patient had multiple fractures at C3/4. Figure c. Shows the patient after the surgical repair. A screw-plate fixation was administered to stabilize the segment.
References


Figure 3d,e. This lateral and AP lower cervical show the screw plate fixation of the same patient. Clips are also noted in the disc spaces.
Section IV– Other Extremity Orthopedic Hardware and Advanced Imaging

General Information on fracture repair

As one would expect, some fractures are easier to treat than others. For example, displaced and comminuted fractures (fragmented fractures) often lead to delayed union because the gap has to be bridged and soft tissue may be interposed between bone ends making bony union impossible. Transverse fractures heal more slowly than spiral fractures because there is less surface area of contact and due to the high energy nature of the inciting injury. Joint involvement will delay union because of the fracture hematoma dilution by synovial fluid.

Here is the Perkins rule of thumb law. The law states that a spiral fracture of the upper extremity takes about three weeks to unite; double this to consolidate; double this for the lower extremity; double this if it is transverse; double this if it is open (impacts more than bone); 1.5 times if an adult; double it if undertaking sports.

Beyond the fracture itself, the patient may cause the delay of healing. The rate of healing decreases as the patient reaches skeletal maturity so age is a factor. Patients on NSAIDS (non-steroidal anti-inflammatory drugs) or corticosteroids have delayed healing since inflammation is what promotes healing. Poor nutrition can delay healing. Other pathologies such as diabetes, osteoporosis, malignancies or HIV can impact healing. Vices such as cigarette smoke reduces the blood supply which is required for healing.

While closed reduction is appropriate for many patients, those with the above mentioned circumstances may require surgery in order to obtain adequate fracture healing.

Key points:
- The more complicated the fracture, the more likely surgery is required
- Co-morbid factors often slow healing

Distal radius fracture repair

The distal radius fracture is commonly caused by a fall on the outstretched hand from a standing height. The patient trips and catches the fall with the wrist. Other common causes for this fracture are motor vehicle accidents, falling from great heights, and sport related trauma. If the fracture is uncomplicated, closed reduction and splinting is appropriate. However, unstable or unsuccessful closed reduction may require open reduction and internal fixation with a dorsal plate.

The main complication of the dorsal plate placement is extensor tenosynovitis. Extensor tenosynovitis is diagnosed by dorsal wrist swelling and crepitation with wrist or finger motion. Conservative treatment can ensue such as splinting or anti-inflammatory medications and procedures. If after six months, there is not adequate resolution of the symptoms, then the hardware can be removed.
Usually, the patient catches the fall with the wrist extended and this is called a Colle’s fracture. If however, the patient lands on a flexed wrist, instead of the dorsal angulation to the radius fracture seen in a Colle’s fracture, the radius fracture will have an anterior angulation. This is called a Smith’s fracture. I don’t know who started this memory tool but I learned it as, “Mrs. Smith is on the front porch while her dog is in the backyard”. Smith’s fracture has the fracture fragment angling forward while the Colle’s fracture has it angling backward. The angulation will determine the plate placement as seen in the following figure.

![Figure 4a,b. Anterior plate placement with intramedullary screws in this distal radius fracture](image)

The procedure for dorsal plate fixation is as follows: five cm skin incision and release of the extensor pollicis longus tendon, elevate the extensor retinaculum, place the plate on the radius, then repair the extensor retinaculum with sutures. The plate is either made of titanium or steel. After surgery, the wrist is immobilized with a volar splint. Start with active and passive finger motion. After one week post-surgery, start active and active-assisted motion of the wrist. At six weeks, passive motion of the wrist and grip strengthening exercises can ensue. Union is defined as radiographic healing within six months.

**Patellar fracture repair**

One percent of fractures occur in the patella, where most are transverse and affect the middle third of the patella. Most patients are male and aged twenty to fifty. The injury is typically the result of falling on a flexed knee or motor vehicle accidents. The choices for patellar surgery are the following: percutaneous arthroscopic techniques, tension band wiring, and plate fixation. The advantage of
percutaneous arthroscopic techniques is that there are less complications but the surgery is technically demanding. The tension band wiring is an easier surgery but requires a large incision which means prolonged rehabilitation and higher risk of complications. The most likely complications to patellar surgery are infection, patellofemoral arthritis, and impingement or irritation of the skin over the knee. Sometimes the irritation makes removal of the hardware necessary. The newest technique is called the anterior low-profile mesh plate. The plating is the best option for comminuted patella fractures.

Figure 4c. Classic transverse fracture in the middle third of the patella with repair.

Key point:

- The choices for patellar surgery are the following: percutaneous arthroscopic techniques, tension band wiring, and plate fixation.

Advanced imaging

This course has focused on the appearance of orthopedic hardware as seen on plain film. Advanced imaging can be utilized on patients with orthopedic hardware. Most people would say that metal and magnetic resonance imaging (MRI) do not mix. The answer is that it depends on the metal. Titanium shows less artifacts than those implants made of cobalt chromium. The quality of the image is also dependent upon the pulse sequence parameters set by the radiologist. Fast spin echo shows less metal artifacts than spin echo imaging for instance. Now that you know that you can use MRI, when would it be clinically indicated? The most common applications are for painful shoulder, knee, and hip arthroplasty evaluations. The MRI evaluates the integrity of the rotator cuff tendons and for knee and hip, the surrounding ligaments, muscles and tendons can be visualized. These soft tissues would not be
evident on plain film. For evaluating the arthroplasty, MRI is superior to plain film at identifying osteolysis with a ninety-five percent sensitivity for detection, ninety-eight percent specificity and ninety-six percent accuracy.

Ultrasound is a great but underutilized tool in the United States. It is cheap, has dynamic capabilities and lacks ionizing radiation. With orthopedic hardware implantation, there is a characteristic reverberation artifact produced with ultrasound. The polyethylene liners used in joint replacements demonstrate a sharp echogenic linear interface with “posterior acoustic shadowing”. Because the metal and polyethylene look different from one another on ultrasound, this device is valuable to look for subluxation or polyethylene wear. The dynamic capabilities are valuable because the patient can be maneuvered into provocative positions and evaluated when post-operative pain is a concern. Power Doppler can identify active inflammation, such as that found in synovitis and active infection.

The last imaging modality to discuss is computed tomography (CT). While conventional CT is not overly useful due to the beam-hardening artifacts created by the metal, three-dimensional (3D) CT can be used to detect subtle fracture healing, confirming non-union and for hardware integrity evaluation.

Key points:
- Advanced imaging modalities such as MRI, ultrasound, and CT have some usefulness in the evaluation of patients with orthopedic hardware.

References


Section V – Complications of Orthopedic Hardware

Potential complications in all orthopedic hardware surgeries

Perioperative mortality with hip fractures is ten percent at one month, twenty five percent at one year for women and thirty percent at one year for men. These percentages have remained the same over the past forty years, despite advances in medical care. Thus, complications need to be avoided. There is universal concern with all insertion of orthopedic hardware. From an imaging point of view, the key is
looking for radiolucent areas around the orthopedic hardware on plain film. A homogenous dark area following the plane of the hardware will indicate loosening. How much radiolucency is too much? For example, in the knee arthroplasty, radiolucent areas that are less than 2 mm and nonprogressive are not abnormal. Concern occurs with progression or radiolucent areas exceeding 2 mm. If the dark area is a well defined lesion that looks osteolytic, mimicking a tumor appearance, the patient may be suffering from small particle disease. Small particle disease is rare but does occur following arthroplasty. The condition is an inflammatory response due to wear debris. This inflammation causes the osteolysis. The particles resulting from the wear debris incite macrophage activation and phagocytosis, thus ending in joint loosening and implant failure. With that being said, just because particle disease mimics a tumor, it does not mean that the patient could not truly have a tumor. Be sure to note the history and why the patient had the hardware implanted in the first place. Osteolytic tumors can undermine the osseous integrity to the point of requiring arthroplasty for stabilization; therefore, a recurrence of a tumor could be the cause of the osteolysis.

Other areas of concern include periprosthetic fractures and failure of bone grafts to incorporate. Bone grafts are commonly used for the treatment of bone defects. Hardware fracture or dislocation is another concern. Below are examples of three dislocations after arthroplasty. Remember that hips tend to dislocate posterior and superior while shoulders tend to dislocate anterior and inferior (Figure 5a,b,c).
Figure 5a,b,c. Figure a and b show hip dislocations after arthroplasty. Figure c shows a knee dislocation after arthroplasty.
Post-operative immobility can result in complications. Immobility increases a patient’s risk of infection, pressure sores, morbidity and mortality. These consequences are especially likely after hip or femur surgery. To reduce the risk of immobility complications, start weight bearing early. If the surgery can be performed within twenty four hours after hospital admission, studies have shown a reduction in minor and major complications. Poor bone quality can increase the patient’s recovery time and predispose him/her to future fragility fractures. Thus, identify and treat correctable causes of poor bone quality to prevent complications. Common causes of secondary osteoporosis include autoimmune disease, glucocorticoid therapy, malignancy, hormonal suppressive agents for breast or prostate cancer, hypercalciuria, HIV, celiac disease and malabsorption. Check vitamin D levels as up to ninety percent of patients with hip fractures have been found to have insufficient levels of vitamin D. Osteoporotic bone can still have successful outcomes as long as accommodations are made during surgery to augment the bone, like using different cements, such as calcium phosphate cement, or allograft struts can be placed along the diaphysis to hold the screws or stabilize wires. Cement can be injected in the screw holes just like any other carpentry project.

Key points:

- Complications include but are not limited to the following: small particle disease, loosening, infection, periprosthetic fractures and dislocations, bone graft failures, and pressure sores

_Fracture complications and orthopedic hardware_

*Figure 5d-orthopedic hardware*  
_repairing a proximal femur fracture*
Before discussing what goes wrong, first identify how normal healing occurs. There are two processes by which a fracture heals: callus formation or secondary bone healing. Secondary bone healing is the natural process of healing of long bones when no rigid fixation has occurred. Callus formation occurs in response to movement. When orthopedic hardware is administered to stabilize the fracture, primary bone healing occurs via direct union.

Blood flow is responsible for nutrient delivery and thus must be of first priority in fracture healing. In the first few hours, blood flow to the area declines. (In order to repair a leaky hose, you must first turn down the water pressure to do hose repair). Soon after, the blood flow will rise until peaking at two weeks. The extra blood brings the required nutrients for fracture repair. After three to five months, the blood flow returns to normal.

Key points:

- The type of bone healing will be determined by the amount of motion occurring at the fracture site
- Blood flow is a major contributor to normal fracture healing

How the blood supply is impacted by the fracture is an important cause of complications. For example, intracapsular fractures of the femur or scaphoid neck are prone to delayed union or nonunion. This is
because the blood is supplied by end arteries. If they are severed, the bone distal to the impacted artery will die and fail to heal. There is no other artery available to nourish the bone. Severe periosteal or soft tissue trauma can impair healing and so can large interfragmentary gaps or inadequate immobilization.

One way to promote healing is with pulsed electromagnetic fields (PEMF) and ultrasound. These methods alter cell proliferation and promote bone formation. This goal is accomplished through the stimulation of growth factors and proteins that remove old bone and increase the rate at which fibrous matrix is converted to mineralized bone. Cancellous bone heals faster than cortical bone because of the large area of bony contact and more active bone cells being present.

Key points:
- Complications specific to fracture repair include: end artery compromise, interfragmentary gaps, and inadequate immobilization
- PEMF and ultrasound can help speed recovery following fracture repair

Complications in special circumstances

Comorbidities play a large part in the post-surgical outcome of the patient. Common comorbidities include cardiac disease, renal disease, pulmonary disease, malnutrition, sarcopenia, and dementia. Be cognizant of patients who suffer from delirium as it increases the complication rates after surgery. Delirium is characterized by an acute onset of symptoms with a “fluctuating course of disorientation, confusion, agitation, and decreased attentiveness.” Delirium can come in three forms: hyperactive, hypoactive, and mixed. Unfortunately, up to sixty-one percent of patients with hip fracture experience postoperative delirium.

Key points:
- Comorbidities greatly affect the outcome of the patient
- Postoperative delirium is common and needs to be identified in affected patients

References