# *"ORTHOPAEDIC PEARLS"*

## *"Stuff" Orthopaedists Should Know That Isn't Easily Found in Text-books*

This booklet was written to try to provide quick and easy access to knowledge that is generally taught person to person rather than in books. Much of it we learned from our teachers, our colleagues and our residents. You may feel that some of it is wrong (and you might be right) however we hope that most of it is of some use to you. We welcome constructive criticism and additional pearls.

Laury Dahners Doug Dirschl

# Clinic

**Sit Down!:** Studies have shown that patients perceive that physicians spend greater time with them when physicians sit down in the exam room than when physicians stand throughout the patient encounter, even when the encounter times are identical. Get in the habit of sitting to interview each patient; it does not necessarily slow you down, but the patient will likely feel better cared for than if you stand for the entire encounter.

**"Point to it with one finger":** We all tell patients to do this when they confuse us with diffuse symptomatology but, next time you are injured, try to localize *your* pain to a single spot. You may be surprised how difficult this can be. Nonetheless, it is confusing for us when patients magnify their symptoms in hope of attracting your attention. A classic example is a patient who claims his "entire leg is numb." Our reaction is that this is a non-anatomic complaint, and therefore we assign the patient a high porcelain titer. Try to remember that even though the patient's worst numbness may be in his great toe web space, the remainder of the dermatome will have some numbness in it and it does overlap several other dermatomes. In addition, the patient may well feel that you are unlikely to be impressed if he tells you that the only place he is completely numb is in his great toe web space! You may find that including the patient in your diagnostic effort by telling him that you need to know where he is "most numb" or "most painful", etc., may be of great help.

**Cancer:** Remember that patients who come to the clinic with seemingly minor complaints may be most concerned that those "minor complaints" are signs of some dread disease, such as cancer. Reassuring them of what "their disease is not" may be as important as telling them what it is and suggesting they take a little NSAID for it.

**"This isn't like heart surgery":** Using this phrase can assist patients in understanding that, while degenerative orthopaedic conditions (such as osteoarthritis) are painful and limit function, they are rarely life-threatening. Thus, surgical procedures to address these conditions are elective, and it is helpful if you assist the patient in reaching the understanding that he/she is, at least in part, responsible for making the decision about when to do surgery.

**Appearance:** Your appearance may not seem to you to have any bearing on your effectiveness. However, the patient is trying to judge whether you are a good surgeon from minimal data! While the patient may not object to your sloppy appearance on a conscious level, subconsciously the patient probably wants someone with a clean, neat, and efficient appearance to be doing his/her cutting. At some point your livelihood may depend on your ability to attract patients and your grooming will become very important to you! When you show up to clinic unshaven, in wrinkled clothing and with a coffee stained lab coat you are damaging the "patient attractivity" and thereby the livelihood (only the patients who can't pay will still come) of the residency program that is supporting and training you.

**Diagnostic injections:** Patients vary greatly in their pain threshold. Sometimes the most important thing that a diagnostic injection can tell you is what that patient's pain threshold is. Always try to record the patient's degree of pain relief five or ten minutes after the injection, as they will often return to clinic several weeks later telling you it did "absolutely nothing." In fact it may have been very effective for a short while but they are confused by the fact that they actually felt worse several hours after the injection.

"**An unstable fracture":** This term is frequently used but poorly defined. It often denotes fractures that must be treated operatively but sometimes is used to recognize those fractures which are difficult to stabilize even operatively. A clue – most "unstable fractures" occurred under axial load and the bone is no longer capable of maintaining its own length (withstanding compression). Thus casts or plates which maintain "alignment" well, but do not maintain length well, fail -- leading to the conclusion that the fracture is "unstable."

**Casting learn** to apply your plaster rapidly so that you have plenty of time to rub. Rubbing and molding are the most important parts of cast application, as they laminate the layers together for increased strength, smooth out the inside of the cast by fitting it carefully to the underlying limb, and, (if carried out conscientiously *around* bony prominences) make indentations inside the cast over the bony prominences so that they do not rub. Poorly laid down "tucks" made during rapid cast application are readily obliterated by compulsive rubbing and molding.

**Casting -- Pinky fingers and toes:** Patients occasionally complain about an ugly cast, but they will always complain if their small finger or pinky toe is trapped and painful in the cast. Be certain to trim each cast to provide room for the little finger and small toe. Upper limb casts should be trimmed to expose the small finger MP joint, while lower limb casts should be trimmed to expose the entire small toe.

**Clinic billing:** When you are starting out, you often feel like you are charging too much for the service you provide. In addition patients complain that "I had to pay $75 to see the doctor for 10 minutes?!" Please remember that the bill submitted doesn't just pay for the service you provide, but pays for: a) the secretary's time scheduling the appointment, b) the secretary's time signing the patient in to clinic, c) the nurse's time putting the patient in the room, d) any disposable sheets, gowns or shorts the patient wears in the room, e) any gloves, dressings, and other supplies used during the visit for which the patient is not charged, f) the secretary's time signing them out and scheduling new appointments, g) the billing office's time for submitting and collecting the bill, h) rental of the space in which the patient is seen, i) the preparation of a medical record clinic note ($.10/line, average note 25 lines = $2.50/note), j) any letters written to employers-lawyers-insurance companies, k) malpractice insurance, l) the cost of treating patients who cannot pay, and finally what's left over (not as much as you might think) goes to, m) paying the doctor's salary.

**"I don't know":** You don't always have to answer weird questions (i.e. "Why do my toenails hurt?"). The patient won't lose respect for you and, in fact, often respects you more for your forthright honesty (certainly more than they do for a bunch of *wrong* answers--consider alternative practitioners and some of their nonscientific diagnoses such as "spinal alignment" problems).

**"My lawyer told me to ask you....":** Patients who have personal injury lawyers frequently utter this statement. It is a drain on your time to try to give the patient verbal answers to the lawyer's questions, and it is unlikely the patient will accurately convey the answers back to the lawyer. In this situation, it is best to quietly and calmly let the patient know that it is unfair for him/her to be placed in the role of information courier. Explain that this method of communicating information is seldom accurate and that you will gladly answer the lawyer's questions if he/she will send them to you in writing.

**Disability Evaluations -- Important Terms:**

**Maximal Medical Improvement (MMI):** The point in time following an injury when the physician determines the patient is "as good as he's going to be", or when he has recovered as much function of the injured part as he is likely to recover following a particular injury. Permanent partial impairment is determined once a patient has reached MMI, and impairment ratings should not be given before a patient has reached MMI.

**Impairment:** What the physician determines. It is the amount of deficit, usually expressed as a percentage, in an injured part compared to what it was in the normal state (usually prior to injury). It is determined based on objective medical findings and its determination is aided by state guidelines for workmen's compensation and an AMA guide otherwise. It is a medical determination of the patient's functional capability.

**Disability:** What the insurance company or Worker's Compensation Board determines. This is how much the permanent partial impairment is worth to the patient in dollars and cents. This is calculated based on the physician's rating, but the monetary payment to the patient is not determined by the physician. Many patients do not understand this -- you should assist them in understanding your role in the process of settling disability claims.

## On the wards

**Surgical nutrition:** Consists of adequate: 1. calories, 2. protein, 3. vitamins and 4. minerals. Other concerns, i.e. fat, fiber, food groups are not necessary for the surgical concern of wound healing.

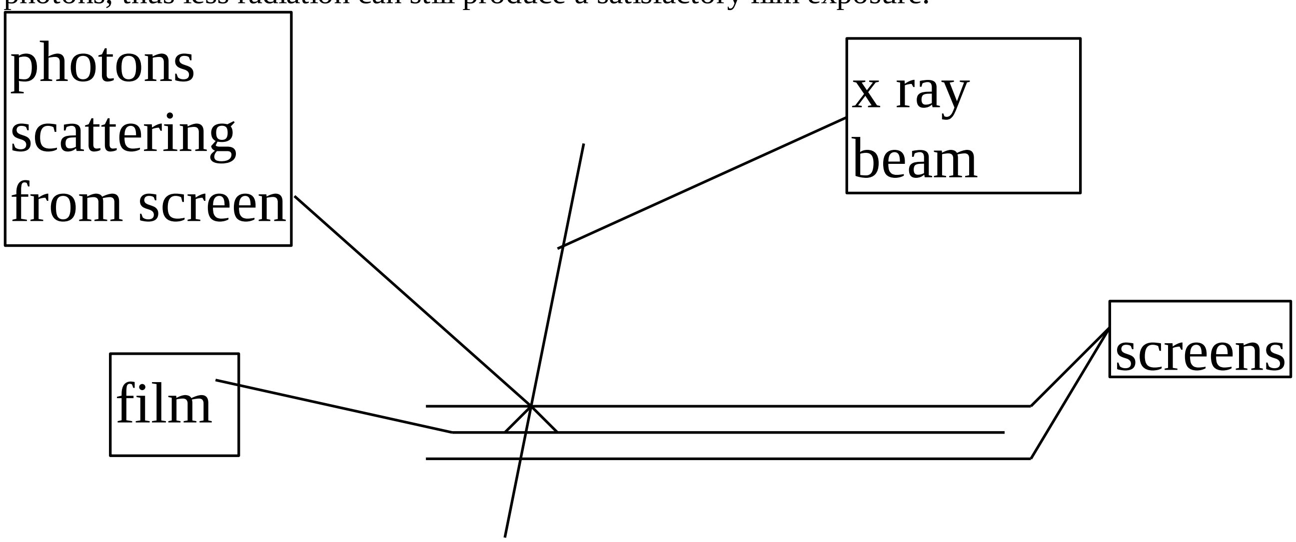
**Achieving adequate surgical nutrition:** This can be difficult in some patients, especially alcoholics. However many alcoholics will eat peanut butter if it is provided in large quantities and they are encouraged. It is high in calories and protein. A vitamin and mineral supplement can be given to round out the program. Good lifelong nutrition? No, but it might get the wound healed!

## X-Rays

**Copies:** You can tell a copy from an original x-ray because it has little notches cut in the end of the film.

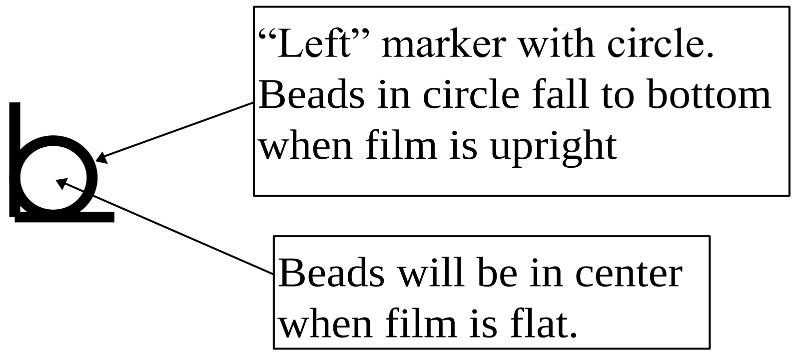
**"Coning down":** This refers to the narrowing of the beam to only expose that part of the body you are specifically interested in. When the beam exposes surrounding tissue, x-radiation is scattered by the surrounding tissue and fogs the portion of the film that you are specifically interested in. This is why the quality of films that expose large parts of the body is not nearly as good as a carefully "coned down" film exposing just the area of interest.

**"Screens":** Screens are devices placed within the x-ray cassette, which actually fluoresce when exposed to x-radiation. This fluorescence also exposes the film to light photons, thus less radiation can still produce a satisfactory film exposure.




The problem is that the fluorescence of the screen slightly diffuses the image, making a poorer quality image. If you want an especially high quality film, you may need to use cassettes without screens and a more powerful x-ray beam.

**Upright films:** If the films are not marked, it is often possible to tell whether they are upright (if the abdomen is within the x-ray field) by the presence or absence of air fluid levels. You should know that the right and left markers used by many x-ray departments have three little lead beads within a circle.




These beads fall to the bottom side of the circle if the film is placed upright, but remain in the center if the film is flat.

**Fluoroscopic radiation exposure:** The image intensifier on a fluoroscopy unit allows the use of very low doses of radiation. This means that fluoroscopy units, in general, produce less radiation than obtaining ordinary films. During surgical procedures, the highest dose is to the hands, but Sanders et al. (JBJS 75A:326) calculated from their study that the average surgeon would need to perform 7,614 fluoroscopy assisted procedures per year to reach the limit recommended by the government for the hands. Nonetheless, one's best protection is distance from the x-ray beam (and the tissue that is being radiated and scattering x-rays), as dose falls as the cube of the distance. A surgeon must not become cavalier.

**"God is in the detail":** Visual acuity is high only at the fovea of the eye. This means that if you glance at an x-ray without actually making your fovea cross all the important parts, it is easy to miss minor flaws. A wise practice is to trace the surface of each bone with your eye to ensure that the fovea will pass close to all of the important parts of it.

**Densities:** There are only five different densities that can be seen on plain x-rays: (1) Air; (2) Fat; (3) Soft tissue/water; (4) Bone; and (5) Orthopaedic implants. Recognizing this limitation makes it easier to understand what you are looking at. If you think you can see a soft tissue structure, it is probably because it is outlined with fat (such as psoas shadows on spine films, the psoas is the same density as surrounding tissue, but its surface fat outlines it).

**"The worst looking view is the one that speaks the truth":** When trying to determine whether union has occurred, if several views appear to show bridging bone, but one shows a clear defect then the "worst view tells the truth." The apparent bridging is an artifact of the two bones overlying one another. The same is true with alignment. If one view appears to show a step off or angulation but others do not, assume the worst. If you are actually **trying to find** a gap or defect, i.e., "Is the heterotopic ossification actually Brooker grade IV (complete bridging), or is the screw outside the joint?" then the view that looks best is the one that speaks the truth.

**“Occult” femoral neck fractures:** Femoral neck fractures are usually most visible on a 20$^o$ internally rotated AP view, which corrects the tilt of the anteverted femoral neck and throws it into complete profile. If you are worried about an occult femoral neck fracture, it is worth getting this film before obtaining a bone scan. When the patient has a femoral shaft fracture, you **can’t** internally rotate the femur and so **must** tilt the beam.

**Dark films:** If you are trying to see a dark film and do not have a bright light available, you can roll up another x-ray film into a small tube and look through the tube at the x-ray with your other eye closed. The rolled up x-ray will exclude extraneous light, allowing your pupil to dilate and thus allowing visualization of even a dark film.

**WNL (we never looked):** Don’t order preoperative chest x-rays on patients who don’t have an indication for them. If you do order a preoperative chest x-ray, **check the report.** If you miss a lesion and ignore the report, you will be found guilty.

**Forearm rotation:** The bicipital tuberosity is on the same surface of the radius as the articular surface for the distal RU joint. The ulnar styloid is on the dorsal/posterior surface of the ulna (opposite the shaft of the humerus). These two facts can be very useful in assessing the rotation of the forearm bones radiographically.

**CT “edge effects”:** Although they appear on the final printout as if they are infinitely thin slices through the body, CT slices do have a finite thickness. This means that a structure that extends halfway across that finite thickness will appear to be half as dense as it actually is and may have an odd contour due to the obliquity with which the surface of the structure crosses the slice. Being aware of this possibility can make it easier to interpret odd appearing structures that are merely artifacts of this edge effect.

# Procedure Techniques

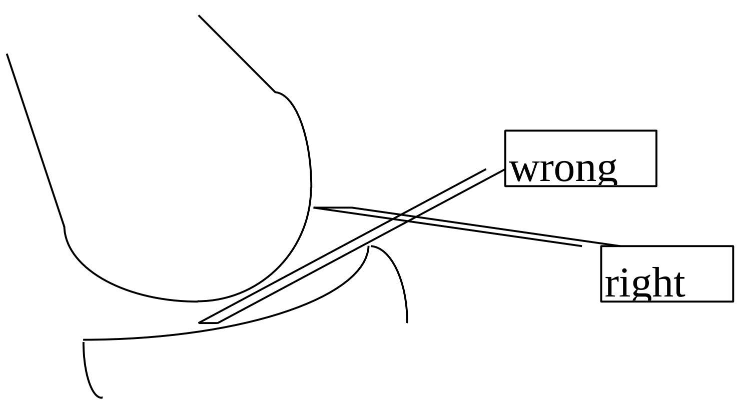
**Outpatient/Emergency Room Procedures:**

**Failed blocks:** Many “failed blocks” (hematoma blocks, nerve blocks, etc.) are due to surgeon impatience. It can easily take 15 to 30 minutes for the block to reach its maximum effectiveness. Do your paperwork while you’re waiting. Another cause for failure is use of insufficient volume of anesthetic. One study has shown that attempting to do hematoma blocks of the distal radius with less than 12 to 15 cc of 1% Lidocaine results in a much lower success rate. Larger bones require larger volumes.

**Postreduction x-rays:** It takes a while from the time you order a postreduction xray until the patient is actually taken to the x-ray room. You needn’t always be frustrated by this delay, which can occasionally be lengthy. Think ahead and order the postreduction x-ray after you have inserted your hematoma block, just prior to performing the reduction. The sometimes slow process of entering the order, etc., can be taking place while you are performing the reduction, and the patient may be ready to go to x-ray just as you finish molding your splint.

**Reduction of dislocations:** It is probably much safer for your patient to reduce dislocations after intraarticular injection of anesthetic (which can be surprisingly effective at pain relief) rather than excessive use of intravenous sedatives and narcotics with their attendant dangers. A dislocated joint is frequently surprisingly easy to inject by introducing the needle on the opposite side from the dislocation (i.e., introducing the needle posteriorly for an anterior dislocation of the shoulder or anteriorly for a posterior dislocation of the hip). Even the hip, which usually must be aspirated in fluoroscopy, can often be injected without fluoroscopy (when it is dislocated) by introducing the needle lateral to the femoral pulse and walking it off of the pubic ramus until the needle falls into the hip joint (with a located hip, you cannot feel this drop off so that you need fluoro to tell you are in the correct position).

**Injecting a dry joint:** Many physicians make the error of trying to insert the needle into the “joint space.” **There is no space there!** It simply appears to be a space on x-ray because of the cartilage. Trying to insert the needle into the “joint space” results in numerous longitudinal lacerations of the articular cartilage by the needle as you “fish in and out” for the space. In a joint that does not have an effusion, it is least damaging to direct the needle perpendicularly into the articular cartilage of the convex surface of the joint (i.e., femoral condyle of the knee, talar dome of the ankle, etc.) making one small round hole in the cartilage. Once the needle is against the subchondral bone, depress the plunger and back the needle out slightly until fluid flows in freely. This one small round needle hole is much better for the joint than numerous longitudinal lacerations.




**Painless injections:** There are several things that can be done to diminish the pain of an injection: (1) Rub an anesthetic cream into the area. Unfortunately this requires a long waiting period. (2) Ice the area or spray with a cold spray. (3) Use a sharp needle. Be aware that putting a needle through a rubber stopper damages its fine, sharp tip and that not all needles are sharp directly out of the package. A dull needle will cause dimpling of the skin and should be discarded and a sharp needle (which passes easily through the skin without dimpling) used instead. (4) Inject slowly. It may well be that the reason a small needle hurts less than a large needle, has as much to do with the fact that it is difficult to inject rapidly, as it does with the size of the needle itself. (5) Distract the patient with a nonpainful sensory stimulus such as rubbing the area near the injection with your other hand, as other sensory input blocks the brain's perception of pain sensation to some extent. (6) When anesthetizing a wound, inject through the wound rather than through the intact (sensate) skin.

**Fingertip amputations:** Be aware that children are capable of growing back or "regenerating" fingertip amputations through the distal phalanx (essentially as long as the nail root is still present they can grow back a pretty normal looking finger). This occurs up to age 12 **as long as the wound is not sutured**. Simply wash the amputation, leave it open, bandage it, and begin changing Band-Aids on a daily basis. A much more cosmetic and functional result will be obtained than with debridement and closure or grafting.

**Cast burns:** It is possible to burn people with the exothermic reaction of hot plaster. Factors which increase the likelihood of this are: (1) thin cast padding; (2) thick slabs of plaster; and (3) dipping it in hot water (not because the hot water adds to the burn, but because it speeds the exothermic reaction greatly). If the patient complains of burning, you can try placing the cast in ice, but it may be more prudent to remove the cast or splint rapidly.

**Sawing casts:** Because of its reciprocating action, the cast saw will not cut soft tissue, but because it heats up it *can* burn. This is significantly worse with fiberglass. Many people who are inexperienced with the cast saw cause burns by trying to be too careful. You must push with the saw until it plunges through and then jerk it back, so that it is not in contact with the soft tissue for more than a moment, thus it cannot burn. If you try to be careful and cut through slowly, the hot blade will protrude slowly, rest against the skin, and cause burns.

**In the Operating Room:**

**Nerves:** Patients are nervous. Stopping into the holding area to say hi and ask them if they have any last minute questions can really help them out - do it if you can.

**Cure:** A chance to cut is a chance to cure:

**OFAT "Obligatory Anesthesia Fool Around Time":** This frustrating period of waiting in the room while anesthesia tries this or that block before abandoning regional anesthesia and moving on to general is a prime opportunity to go over your surgical plan with the nurses (I think, "Special position? Special prep? Special drapes?" Then I envision myself making each step of the operation, i.e. cutting the skin, dissecting, retracting, reducing, temporarily fixing, permanently fixing, closing etc. in the hopes that I will see each of the instruments I envision using on the back table. Also see “thought process” below). You can also write your post-op orders, fill out a portion of your postoperative note, and get some reading done if you have a copy of a paper or two in your back pocket.

**OSAT “Obligatory Surgeon Fool Around Time”:** There should be none! The surgeon is ultimately responsible for the patient’s welfare and, if he/she is doing his/her job correctly, will be in the room, having reviewed the instruments and equipment, having gone over the surgical plan with assistants and scrub personnel, and ready to proceed with the positioning and prep **as soon as** the patient is asleep (if not during anesthetization). The surgeon should not rely on the OR staff to call him when the patient is asleep -- if he/she is not in the room by then, OR time ($1000/hour) is being needlessly wasted.

**Thought process:** Rather than letting your mind idle while you are scrubbing, think your way through each step of the surgical procedure again. This is another chance to remind the nursing personnel of any unusual instruments you may need prior to the very moment you need it. Going over it several times in your mind leads to a quick succession of steps and rapid decision making while you are actually performing the operation – the indecisive surgeon is a slow surgeon!

**Scrub:** Many surgeons are surprised to find that Chlorhexidine scrub soaps are more bactericidal than iodine containing scrub soaps. Skin bacterial counts continue to drop with prolonged scrubbing, but the rate of drop diminishes rapidly (geometric progression) so that a ten minute scrub is not much better than a three minute scrub, and a three minute scrub is not much better than a one minute scrub. In addition, repeatedly scrubbing for long periods of time causes skin abrasions and dermatitis, and thus this irritated skin has a higher colony count before the next scrub. Thus, a relatively short one to three minute scrub is much better when a surgeon is scrubbing repeatedly. Bacterial counts on the skin rise rapidly again once surgical gloves are applied and the skin begins to sweat; however, these tend to be skin saprophytes and not as likely to be pathogenic as the casual bacteria found on your skin prior to the scrub.

**Preparing the patient’s skin:** This topic takes on epic, near religious significance with different surgeons and each will chose his own method; however, a few observations are in order. Shaving uniformly increases operative infection rates. The longer it is done before the surgical procedure, the more bacteria will grow in the numerous small skin “nicks” caused by the shaving procedure and the higher the infection rate will become. Obviously, in hairy surgical areas, some of the hair must be removed, but this is best done with clippers immediately prior to the surgical procedure. If a razor must be used, a very light pressure to avoid nicking the skin makes good sense. It is not necessary to remove every hair, only the hairs that will curl into the wound and interfere with the procedure itself, as hair is more susceptible to antiseptic sterilization than the skin itself. Of the antiseptic solutions used on skin, alcohol appears to be the most bactericidal, unfortunately it evaporates rapidly and leaves nothing to kill any bacteria which sweat out of the pores later in the case, so for long procedures, some form of antiseptic that remains on the skin is desirable. In studies, plastic sterile "sticky" drapes have **not** lowered infection rates. This is presumably due to the fact that they cause increased skin sweating, liberating bacteria from the pores *and* almost always peel off before the end of the case, thus liberating the bacteria which have "sweated out of the pores." Therefore, if they are to be used, it is well worth the surgeons' while to expend time trying to be sure that they stick down well and do not peel loose.

**Tourniquets:** Prep solutions which run under tourniquets have been thought to cause full thickness skin loss ("burns"), so it is important that any padding underneath the tourniquet be kept dry. Skin which gets pinched in a fold under a tourniquet *will* suffer a full thickness loss—make sure this didn't happen by running a finger under the tourniquet after application.

**Measure twice, cut once:** There is nothing more dismaying (and litiginous) than to find that you are operating on the wrong extremity! Check before you prep - - Ask the patient before he goes to sleep if possible and mark the operative site with "yes" or the other leg with "no", don't use an "X" because it can mean X "marks the spot" or mean "no." The AAOS advocates "signing" the operative site. This error usually occurs when the operative extremity appears normal, as in arthroscopy. Also, anytime you are about to make an irrevocable cut (as in an osteotomy) check it twice before you cut and find that you went the wrong direction. In the spine, always mark your level and obtain an x-ray, **never** trust a count from a landmark you have found in the wound.

**Skin incisions:** Studies have shown lower infection rates with a single incision that goes all the way through the skin into the subcutaneous tissue. When the skin is cut with multiple "delicate" passes of the knife, little islands of necrotic tissue are left between adjacent passes (that do not go through the vertex of the depth of the incision), and these necrotic islands are presumably the reason for the increased infection rate. This is not to say that you should not use great care in areas with immediately subjacent neurovascular structures (i.e., the hand), but in areas where there are no important subdermal structures (lateral hip incisions), a bold stroke all the way through the skin into the subcutaneous tissue is desirable.

**Cautery:** Cautery smoke is full of carcinogens—suck it up if you can. Using "co-ag" generates much more heat and tissue necrosis than using "cut", thus making your wound more infection prone.

**Obese patients:** Have high infection rates! There is evidence that this is increased by using cautery to cut, thus producing a heat necrosed, poorly vascularized, bacterial growth paradise. Use the knife.

**"Blunt" vs. "sharp" dissection:** Both have their advantages and drawbacks. Sharp dissection causes less tissue trauma and is desirable in dissecting in regions where you are certain there are no important neurovascular structures that might be transected sharply. Blunt dissection produces more tissue injury and in the long-run more scar, but because spreading tends to disrupt tissue along its natural planes, it can prevent injury to important structures.

**Adult bone infections:** Usually one of three conditions are present if the patient cannot resolve the infection with the help of a little PO antibiotic: 1) There is still dead bone or foreign body ("foreign body" including internal fixation devices although infection can often be controlled in the presence of "stable" fixation) in the wound. 2) There is instability, i.e. nonunion or loose internal fixation. 3) The patient is immunocompromised (malnutrition, diabetes, HIV).

**Debriding dead bone:** This is a very difficult task in that dead bone is hard to tell from live bone. If you take out too much you have a difficult reconstruction problem. If you don't take out enough, it's pus party time! Helpful hints: a) soft tissue won't be well attached to dead bone, so dissect gently to recognize this phenomenon. b) live bone will have granulation tissue on it in a chronic wound. c) the interface between live and dead bone will be weakened by resorption – if you grasp the dead bone in a rongeur and twist it, it will often break at this weakened interface. d) when it breaks properly at the interface the remaining bone will look spongy [and bleed]. e) if you give tetracycline for 4-12 months prior to debriding someone with a chronic infection, the live bone will fluoresce under a Wood's lamp (blacklight).

**Bone saws:** Three hints: 1) A new, sharp blade and constant irrigation will keep the heat (bone necrosis) down so that your osteotomy will heal. 2) Sometimes heat is good if you don't want what you are removing to grow back (revision of amputation, Mumford distal clavicle resection) 3) If the pitch of the saw changes from that high annoying whine to a lower hum, it is because the blade is stuck (instead of the small blade moving, the handpiece is moving, and it has a lower harmonic frequency) so pull it back to free it up.

**Speed:** Surgical speed must be balanced against the risk of surgical errors. Both the infection rate and the anesthetic complication rate increase in a linear fashion with the length of a procedure. Therefore, it is desirable to operate as quickly as possible if this does not result in the commission of errors. Recognize that you are more likely to be able to operate quickly when doing a commonly performed procedure in an area which does not have numerous easily damaged neurovascular structures, i.e., a hip fracture. When operating in unfamiliar territory or in the proximity of structures of major importance or when carrying out an unusual procedure, it is wise to slow down and take great care. Recognizing the difference between these situations can keep you out of serious trouble.

**Fast Surgeons:** Surgeons who have consistently short operative times generally do not make quick movements (at least the good ones) rather they do not make wasted movements. If you observe them carefully you will see that they have a plan, they make the steps in the plan in order, they don't stand waiting (if the nurses don't have the instrument they need for a particular step of the operation, they either go on to another step or they find a substitute instrument and make do with it until the nurse finds the proper instrument), and they don't go back to look at some part of the operation they have already completed.

Slow surgeons are indecisive and they dither. They tend to stand around thinking (because they haven't thought ahead), they wait for nurses to get stuff while plaintively complaining that it isn't available (rather than silently blaming themselves for not checking earlier to be sure it was ready), and they piddle back and forth in the wound looking at stuff they've already done while waiting for the lights to come on and tell them what to do next.

**Think Ahead:** An efficient surgeon is always thinking at least one or two steps ahead in the surgical procedure, to be certain the instruments he/she needs next are available and ready for use without delay. Thinking ahead and communicating to the OR staff what will be needed next (i.e. "the next thing we will need on power is a .062 k-wire) will go a long way toward improving the efficiency of your surgical procedures. (Note: a good assistant also thinks ahead, ideally anticipating what will be needed next for the primary surgeon. Don't "zone out" because you are "just the assistant").

**Anatomy:** "To hell with the anatomy, stay close to bone." This common quotation refers to the fact that there are no important neurovascular structures between the periosteum and the bone. The surgeon should always remember, however, that a major portion of the blood supply to the bone comes through the periosteum and that needless stripping of the periosteum results in a marked delay in fracture healing and an increased infection rate.

**Wound irrigation:** "The solution to pollution is dilution":

**Antibiotic wound irrigation:** Antibiotics are agents which kill procaryotic cells (bacteria), but do not kill eucaryotic cells (human cells). Topical antibiotics (such as the Bacitracin, Polymyxin, and Neomycin found in orthopaedic antibiotic irrigating solutions) are called topical because, while they will not kill most eucaryotic cells, they have toxicity to some cells, most commonly renal cells and auditory cells. This means they can be used at concentrations that are bactericidal locally, but cannot be given systemically without causing toxicity to the ears and kidneys. It is important to recognize that irrigating wounds constantly (i.e. postoperatively) with these agents can result in systemic absorption and has produced the complications of deafness and renal failure. If you want to irrigate frequently, Gentamicin and Tobramycin are antibiotics on the borderline between "topical" and "systemic" antibiotics. Gentamicin can be given in concentrations of 200 to 500 micrograms per milliliter (one milligram of Gentamicin per 2-3 cc of saline) without killing fibroblasts or osteoblasts or even significantly reducing their replication; however, few bacteria can survive concentrations over 100 micrograms per milliliter. Recognize that this wound concentration is ten times the concentration (10 micrograms per milliliter) that is expected with a satisfactory "peak" serum level. If you do irrigate wounds postoperatively it should be done on an intermittent, not a constant drip basis. A small constant volume tends to run directly from its inflow to the outflow rather than flushing the whole wound like a large intermittent pulse does.

**Antiseptic wound irrigation:** Antiseptics are agents which destroy all living cells, i.e., alcohol, iodine, phenols, Clorox, hydrogen peroxide, etc. As opposed to antibiotics, most of the antiseptic agents are more toxic to eucaryotic (us) cells than they are to procaryotic (bacterial) cells. These agents are suitable for washing the floor and some of them for washing the already dead epidermis prior to surgery, but are not advisable for washing wounds. While it is true that these agents will kill bacteria within the wound, they will also kill the patients' tissue, creating more necrotic material for bacterial growth postoperatively.

**"Sterile" vs. "dirty":** Sterile (without life) is <u>not</u> the antonym of dirty. If you take dirt and autoclave it, it becomes sterile but remains dirty.

**OR floor:** A surprising but important fact to recognize is that the OR floor may be dirty, but is a nearly sterile environment. This is because it is mopped between each case with powerful antiseptic solutions. The liquids evaporate away, but the antiseptics remain on the floor and are very toxic to bacteria there. Cultures of OR floors show few colony forming units of bacteria. This means that if you drop an especially important piece of the patient on the floor, such as a graft, that it may well *not* be heavily contaminated with bacteria. In one study where bone graft specimens were purposely dropped on the OR floor, left for one minute, and cultured, 50 out of 50 were negative, whereas one out of 50 control specimens sent directly to the microbiology lab was positive. Probably an appropriate step is to place your graft in an antibiotic solution and some have recommended placing it in a closed cup of antibiotic solution, shaking vigorously, and transferring to another cup of antibiotic solution several times to accomplish a dilutional cleaning as well as an antibiotic bactericidal effect.

**Wound closure:** Many surgeons are surprised to find that the tensile strength of Vicryl and Dexon is higher than corresponding sizes of nonabsorbable suture (excepting stainless steel suture). Vicryl and Dexon lose 50% of their strength in three weeks, but by then the wound *should* have healed significantly, thus there are not many situations in which nonabsorbable suture is really needed. Obviously, if you do develop a wound infection, it is desirable to have an absorbable suture that will not serve as a chronic foreign body. Each suture strangulates some tissue - - you need enough to put the tissue in contact so it will heal - - more suture is not necessarily better.

**Hemovacs:** Several studies have randomly compared wounds treated with hemovacs and wounds treated without. Surprisingly, the complication rates are the same or higher in wounds treated with suction drains. This does not mean that in a bloody wound a hemovac may not be a good idea, but routine use of suction drains is apparently not advisable.

**X-rays:** If you are going to get an x-ray to evaluate your surgical procedure, get it in the operating room while you can still fix it if there is a problem. In general, they shouldn't be obtained in the recovery room. There is a tremendous charge for the portable film, the quality is poor, and it is too late to "fix it." If you are not going to get it in the operating room, get it a few days later when the patient can go down to x-ray for a better quality film at a lower cost. In the operating room consider using fluoroscopy, rather than x-ray, so that you can quickly reposition and shoot a better aligned exposure if your position or technique are bad (this prevents accepting an inadequate film because of your frustration over the long period of time it will take to shoot another one).

**Dressings:** Put on a neat one. The patient doesn't know whether you did a neat or a sloppy job inside of him, but the patient may well assume that a sloppy dressing represents the quality of work you did internally.

**Elastic bandages:** It is very easy with Ace wraps and Coban to apply them too tightly. This occurs most commonly when you are bandaging a small area, and rather than cutting off the excess bandage, you go back and forth over the same area several times, adding successive layers of compression. It is easy to produce painful ischemia in this fashion. Thus, wrap your ace wrap loosely and without multiple layers. When you are called about excessive postoperative pain, consider loosening the bandage.

**Intramedullary Nailing:**

**Ball tip guide wire:** The purpose of the ball tip is to allow you to pull the reamer head (which won't slip over the ball) out by pulling out the guide wire (if your reamer shaft breaks). **Do not** be tempted to use non ball tip wires for reaming.

**Reversing the reamer**: Most flexible reamer systems use a spiral wound spring shaft, which only remains intact when twisted in a clockwise direction. If you accidentally reverse the reamer driver while reaming, it can unwind that spiral wound spring into an incredible snarl of tangled wire within the intramedullary canal, which can be impossible to remove. **Do not reverse the reamer!!**

**Preventing guide wire back out:** If the ball tip guide wire is tapped down into the cancellous bone of the distal metaphysis, it often wedges in firmly enough that it does not come out when the reamers are backed out after each pass. This can prevent loss of reduction.

**When backing the reamer out**: Don't hold the guide wire with your gloved hand, as the wire can spin, wrapping up your glove and tearing it. This will contaminate the wire and reamer. If you do contaminate the wire cut off the contaminated part—they are not nearly as expensive to replace as the wasted OR time getting a new guide wire, and reamer system (if it was over the wire when you contaminated the wire you can't get it off the wire without contaminating the reamer driver, reamer and reamer shaft).

**Exchanging the guide wire:** This is done so that the ball tip will not hang up in the end of the nail and make removal of the guide wire impossible. It may not be necessary when your nail has a large cannulation, but is probably always a good idea.

**Incarcerated nails:** The reason you must ream to a larger diameter than the nail you insert is because the flexible reamers do not follow the same smooth arc of curvature that the nail itself does. Thus, the irregular curvature of the reamed medullary canal must be larger than the nail inserted for the nail to pass through. Sometimes even though you have reamed larger, the nail can still become stuck (incarcerated). Signs of impending incarceration are failure of the nail to advance with each blow. **Do not** continue trying to drive the nail, for nails have become so severely incarcerated they could not be removed. Simply take it out and ream to a larger size, then reinsert it. If the nail does become incarcerated, it has been reported that pouring iced saline (available as a cardioplegic solution from the heart room) down the interior of the nail will cause thermal shrinkage of the nail and allow extraction. If this is not successful, the next step is to make a several inch incision over the shaft of the bone in the region where the nail tip is incarcerated and use an oscillating saw to make a longitudinal slot in the shaft of the bone. This will allow the bone to expand by relieving its hoop stress, thus loosening the bone around the nail and allowing nail extraction.

**Screws:**

**Basic principle:** You cannot heal without stainless steel

**Stripped screws:** When you strip a screw here are your options:

1. Redirect (different direction) the screw so that at least the far cortex gives you a new bite.
2. Put in a larger screw (if using a cortical screw, go to a cancellous).
3. Put a nut on the other end of the screw. These are available from Synthes for the 4.5mm screws.
4. Take out the screws that are stripped, numbering them so you know which one goes where. Mix a half batch of cement (I recommend with some tobramycin in it to reduce your risk of infection LED) and pour it into a 10cc “non-Luer lock” syringe while very liquid, injecting it into the screw holes. Quickly put your screws back in before it hardens, but do not tighten until the cement sets up.

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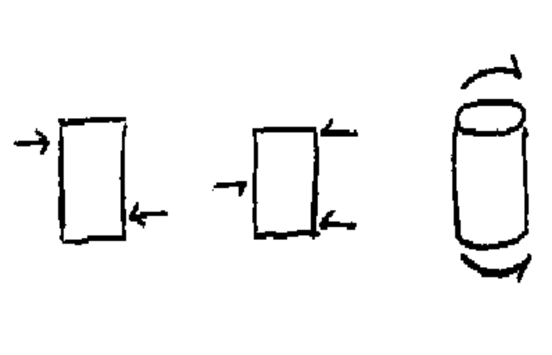
**Choosing a drill bit:** Know the manufacturer’s recommended size! However, if you don’t, drill bits should generally be slightly larger than the root (base of the thread) diameter of the screw they are used to drill for. Thus, if you do not have access to the manufacturer’s recommended drill size, you can choose a drill bit which (Hold them up to the light with the drill bit behind the screw.) extends slightly beyond the root diameter of the screw.

**Removal of broken screws and devices:** This can be very difficult, but a useful trick can be to keep a set of "EZ outs" and tool steel drill bits in your locker. These are relatively inexpensive and can be obtained at an auto parts store. In desperate situations, you can have them autoclaved (they won't tolerate this many times because they are not stainless). You use the tool steel bit to drill a hole in the back end of the incarcerated implant and then screw the "EZ out" into the hole. "EZ outs" have a left handed conical thread which will eventually become too tight to turn and will then begin to unscrew right handed screws or bolts, or at least give you a point of fixation for pulling out nonscrew type implants. With stuck hip screws (implanted at St. Elsewhere and for which you do not have the proper extraction "T" wrench) the "EZ out" will screw into the hole for the compression screw and allow you to screw them out.

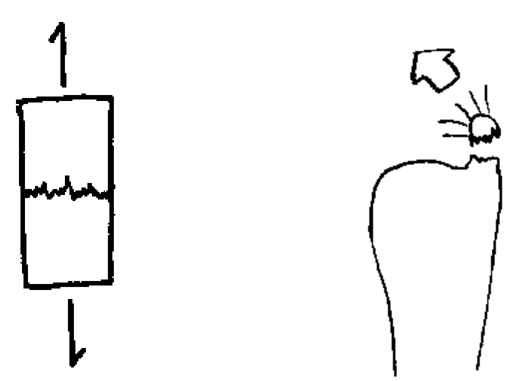
# How bones break under different loads
# (with examples from the distal radius/ulna):

**Types of loading:** Structures, i.e. bones, can be loaded to failure in the following 5 ways.

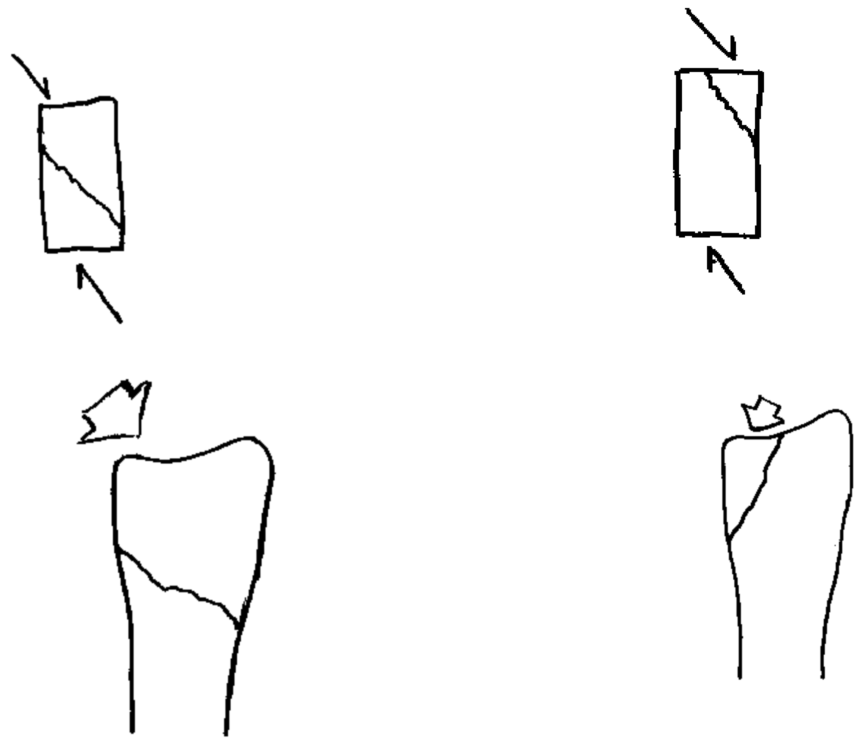


Tension Compression Shear Bending Torsion

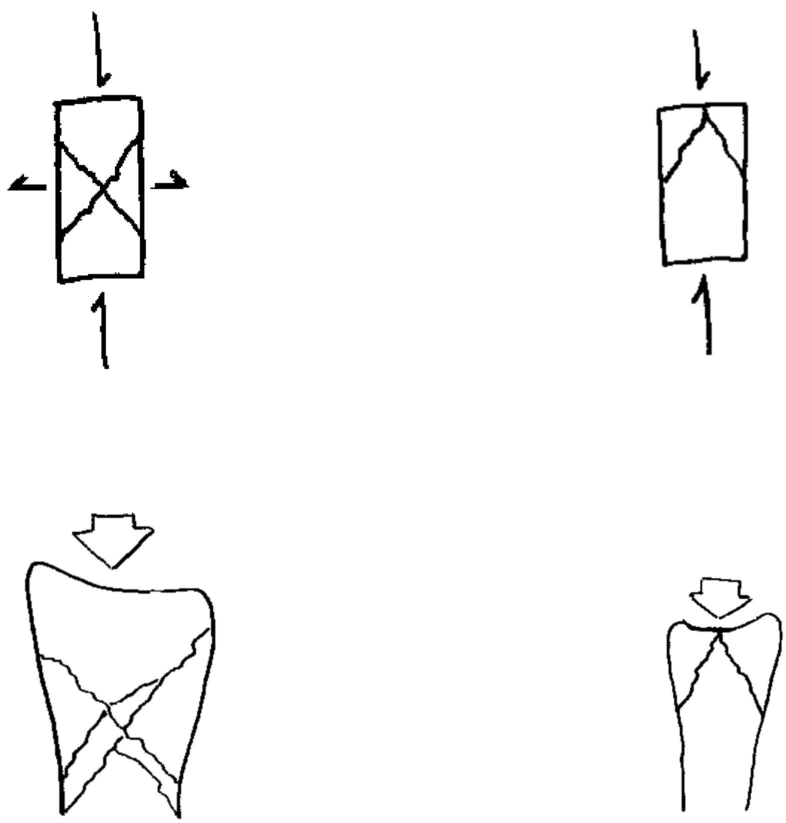
**Failure with tension:** Bone that is loaded in tension fails transversely to the direction the tensile load is applied. This is because the hydroxyapatite is weak in tension and so the collagen (which supplies bone's tensile strength) ruptures across, much like a rope does. Usually tension failure occurs when bone is "avulsed" by strong ligaments or tendons, as in the example, where the ulnar styloid is pulled off.



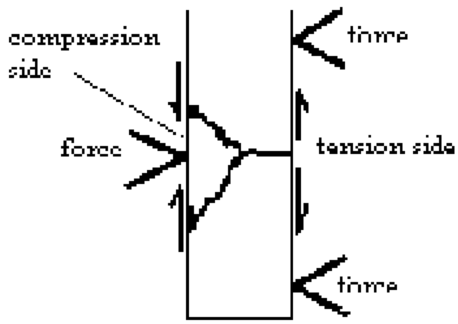
**Failure with shear:** Bone that is loaded in shear fails along a plane parallel to the shear load.

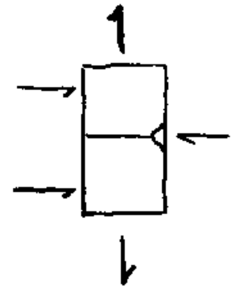


**Failure with compression:** Bone that is loaded in compression can't be "squished down" to a smaller size so it fails along "lines of shear" that are oriented about 45 degrees to the axis of load. This results in the "bursting" of fragments outward from the axis of the bone. Thus most "comminuted" fractures are from compression. The more energy that is imparted (violence) the more the comminution, so that highly comminuted fractures are often associated with severe soft tissue damage and a poor prognosis. For a thought experiment about energy and comminution, imagine tapping a brick barely hard enough to break it – you get two pieces eh? Now hit it as hard as you can, but stand back because you're gonna get hurt by some of the many "bursting" pieces flying off of that "highly comminuted brick!



**Failure with bending:** In bending the bone is loaded in compression on one side (the concave side) and in tension on the other side (the convex side). The bone thus shears out a “butterfly” fragment on the compression side and develops a transverse fracture on the tension side.

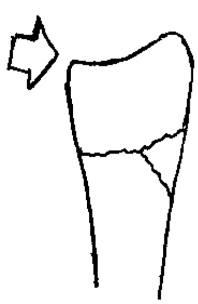


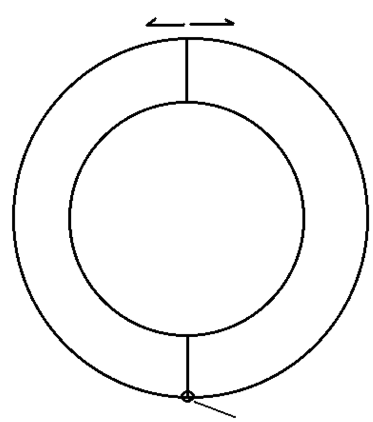



The amount of axial tension or compression that is present with the bending load determines the size of the “butterfly” fragment. The quality of the bone also influences this. Bone in children is weak in compression but strong in tension (as it has good collagen but less mineral), and thus bending loads may “buckle” the compression cortex (also known as a “torus fracture”) rather than shearing out the fragment.

**Failure with torsion:** Torsional loads produce spiral fractures. These fractures hinge open on the straight longitudinal portion with the spiral side “pulling apart.” A piece of chalk or a brittle bread stick make great examples, twist one ‘til it breaks and play with the spiral to see how it fits together.

Cross section through the center of the spiral fx. It opens like a book on the spiral side

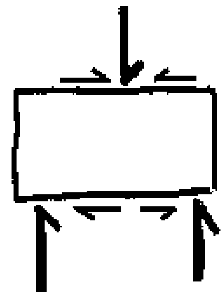




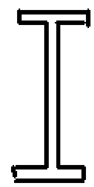
Hinges about this point on the straight side.

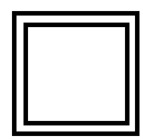
**How to Build a Structure to Resist Various Loads:** If you have a limited amount of material or don't want your structure to be too heavy you can distribute your material in certain ways to make structures that are better at resisting certain kinds of loads.

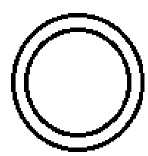
**Tension:** Structures designed to resist tension (cables, ropes, chains) do not benefit from special shapes other than to make sure that there are not narrowed, weaker areas in them, which then become the area where that structure breaks ("a chain is only as strong as its weakest link").



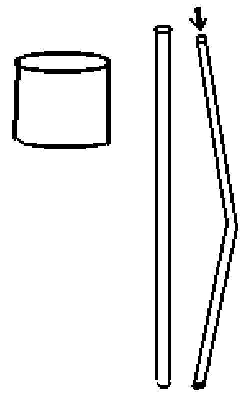
**Bending:** When a structure is designed to be loaded in bending it is called a "beam." Beams sustain tensile loads on one side (if you are standing on a beam supporting a floor, the bottom of the beam is loaded in tension) and compressive loads on the other (in the diagram the little arrows represent the tension and compression produced by the loads represented by the big arrows). The material in the center is not loaded in either tension or compression and is said to lie on the "neutral axis." The best distribution of material for a beam loaded in single plane bending, such as a floor beam is to place most of the material on the top and the bottom and little in the "neutral" (unloaded) center, a so called "I beam" configuration. If the beam is to be loaded in two planes, each at 90 degrees to the other the best configuration is a "box beam." A beam that is loaded in multiple different directions is best designed as a tubular structure. As you will note, bones are loaded in bending in multiple planes and are in fact tubular structures. This follows Wolff's law, which says that bone is removed where it is not loaded and laid down where it *is* loaded. The center of a tubular bone is on the "neutral axis" and is not loaded, so bone there is resorbed. The edge is loaded heavily and so becomes dense cortical bone. Note that the strongest implants we have are the intramedullary nails which also follow a hollow tube design strategy.







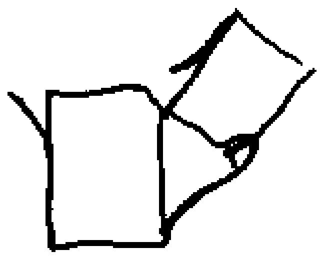
**Compression:** Structures designed to be loaded in compression are called "columns." Short, squatty columns fail by being crushed or squashed (that is how you want your column to fail). Tall thin columns fail by "buckling" (failing in bending) and are said to be "incompetent columns" or to have an insufficient radius for their length. Thus, a good column must be strong enough in multiplane bending to resist buckling and therefore their material also is frequently best distrubuted in a tubular fashion (depending on the material and the length of the column).



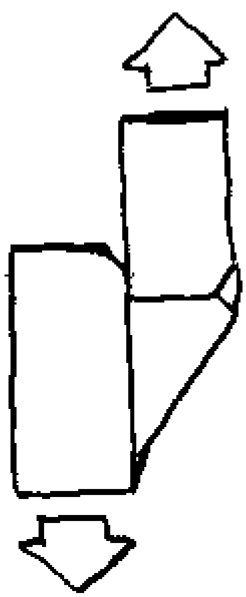
**Torsion:** Structures designed to be loaded in torsion, such as a drive shaft, also turn out to be best designed as tubular structures as material far from the center is said to have a greater "moment of inertia" to resist torsional loads. The easiest way to understand this is to imagine yourself attempting to apply torsion (torque) to a nut with a wrench. It is intuitively obvious that you don't want to apply your load to the wrench down near the nut, at the head of the wrench—rather you apply your load to the end of the wrench handle, as far as possible from the center of the nut, where you have a greater "moment of inertia." In fact torque is measured in "foot-pounds" denoting how far from the center of rotation you apply how many pounds of force. Thus if you want to place your material where it is able to best resist torsional loads you distribute it far from the center (you can also imagine yourself twisting an aluminum wire and an aluminum straw—the straw will be harder to twist to failure).

**Fracture Reduction:**

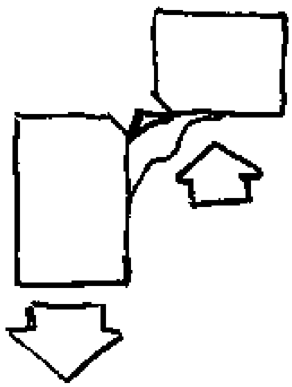
**The displaced fracture:** Casts are best at applying bending loads and not good at distraction of shortened fractures. Because of their significant transverse component (which prevents shortening once reduced), bones which have failed in bending are the best suited to closed reduction and casting**.** Oblique, spiral and comminuted compression fractures won't hold themselves out to length anyway and so frequently aren't worth trying a closed reduction/casting on. In bending failure of the bone, the periosteum and soft tissue is ruptured on the "tension side," and remains intact on the "compression side." This intact soft tissue on the compression side now holds the bone in an angulated position as below (it's on the concave side).



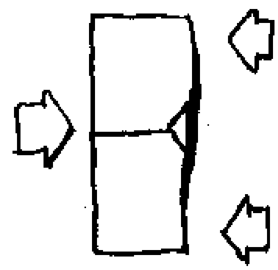
**Applying traction:** If you only apply traction, the situation below occurs where the intact soft tissue on the concave side, being stretched across the hypotenuse of the triangle, is too short for you to obtain sufficient length to reduce the fracture.



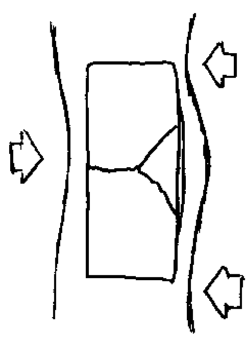
**Increasing the deformity:** If you "increase the deformity", as below, it relaxes the soft tissue on the concave side. If you then push distally on the "side" of the fragment, enough length can be obtained to reapproximate the ends. **This is really only necessary in fractures which occurred in bending!** You *don't* need to "increase the deformity" in comminuted (compression), oblique, or spiral fractures, there's nothing to "unlock."



After the ends are reapproximated, correcting e angulation is easy. The reduction can then be main-ned by applying three point bending (below) in the posite direction as the original deforming force. The act soft tissue prevents overcorrection.



The cast is therefore molded to apply such a three point bend.

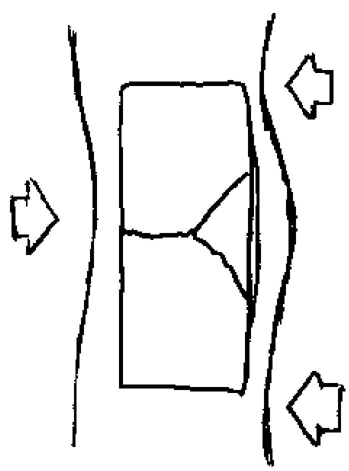


Example in the radius.

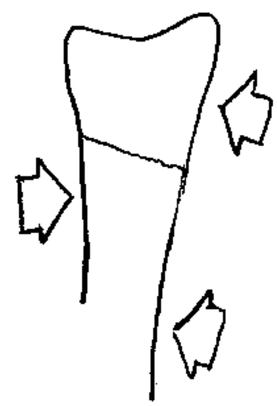
# Fracture stabilization devices
# What they are good at

**The available devices include:** Casts, pins, wires, screws, plates, intramedullary nails, and external fixators. Each can be thought of as being better at resisting (or applying) certain kinds of forces. It is often helpful to think of the kind of force that caused the fracture (described above) and then trying to determine which devices can best be used to "reverse" or counteract those forces.

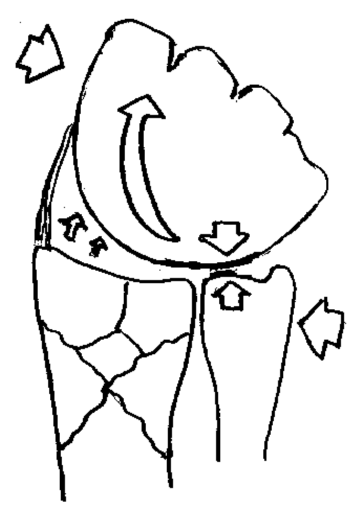
**Casts:** Casts are best at applying bending forces and thus are best used to apply the opposite bending force after reduction of a fracture caused by bending loads.



Casts can, by judicious placement of the "molds" be used to try to "reverse" the deformity of a shear fracture – but they are often unsuccessful, losing reduction as swelling goes down.



Casts can also try to use applied bending loads to produce tension on one bone broken in compression when the compressed bone is paired with another unbroken bone as here in the radius (failed in compression)/ulna intact. Pushing the wrist into ulnar deviation causes the ligaments on the radiocarpal side to pull the compressed radius out to length (called ligamentotaxis. Again this is often not terribly successful. In addition extreme flexion/ulnar deviation positioning tends to result in significant post cast stiffness and dysfunction.

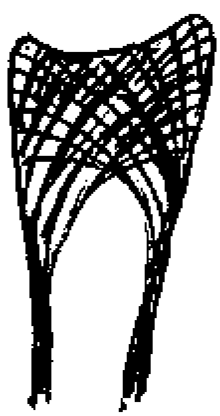


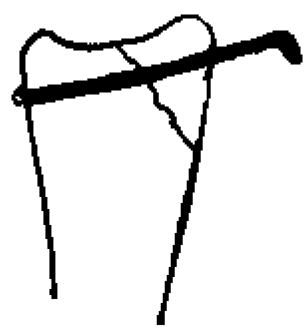
**Pins:** Pins are best at resisting shearing loads and thus are often used to best advantage to fix “sheared off” fragments. They do this best when they are inserted through dense cancellous bone and do not function well in hollow cylinders of cortical bone or osteoporotic metaphysis.

This is demonstrated here by the 16-penny nails used to “pin” this soup can and this two by four, both of which have oblique “shear fractures through them.

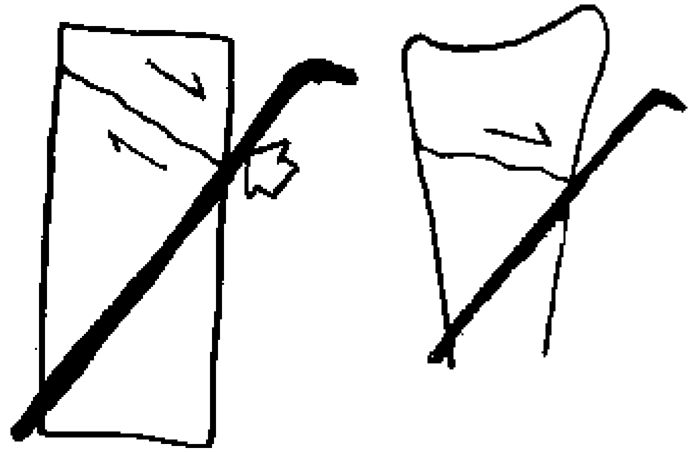

It should not be difficult to imagine how the can will displace, while the two by four will stay firmly nailed.


As the cancellous bone is distributed in the metaphysis and epiphysis of the bone that is the best location for pins, as demonstrated here in the distal radius.

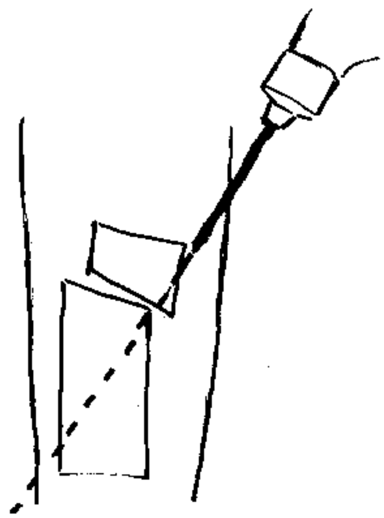


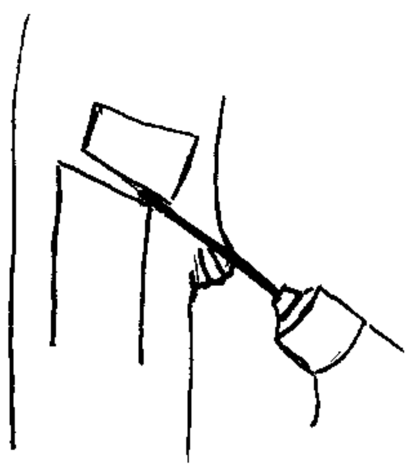


A technique known as "buttress pinning" can make pinning useful in tubular, noncancellous bone. The pin is inserted into the fracture site and then tilted so that it resists shear displacement, then drilled through the opposite cortex.



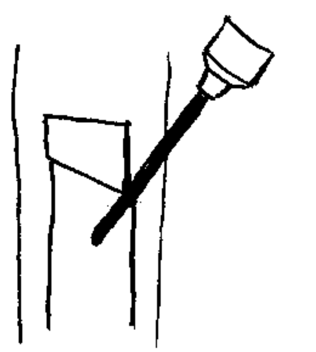
Inserting such pins can be difficult. First you use flouro to determine where the pin needs to be inserted in the skin so that it will enter the bone, at the fracture site, at the correct angle without "tenting" the skin too much when you're done.



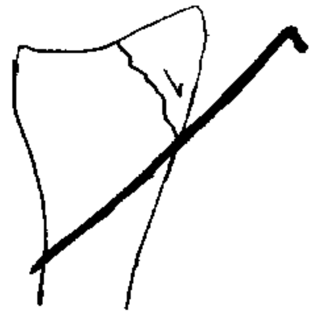


Then you "tent" the skin temporarily to bring the pin to an angle that will allow you to insert it into the fracture site.

Having worked the point of the pin into the fracture site, you tilt the pin back to the original angle (thus reducing the fracture) and drive it into the opposite cortex.

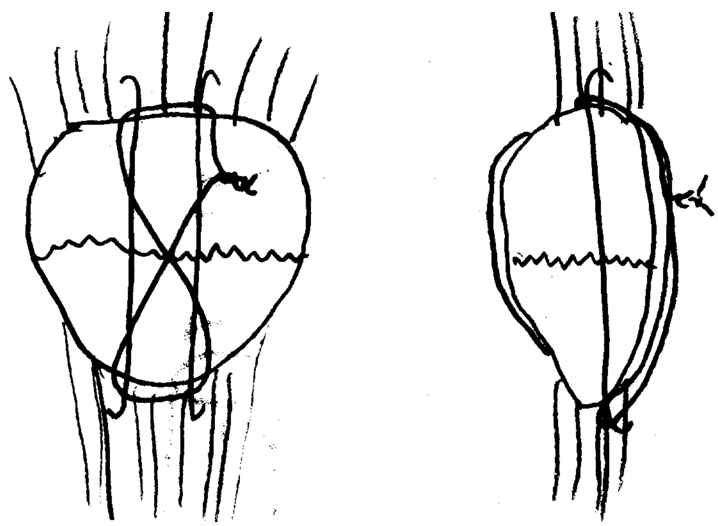


This "buttress pin" technique can also be used to fix sheared off fragments of metaphyseal cancellous bone though the technique is not as necessary in this region.



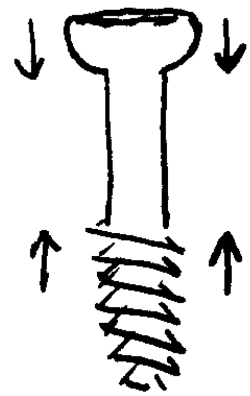
**Wiring**: Wires are best at resisting tension (applying compression). They are frequently called "tension band wires" because the wire itself is loaded in tension.

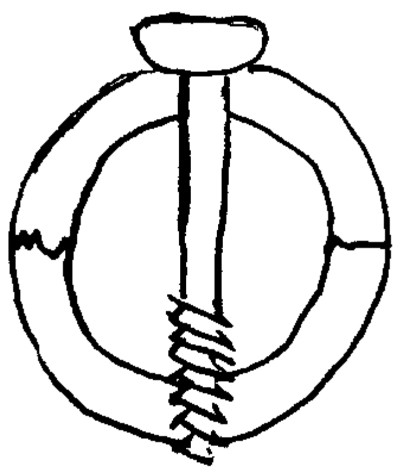
In this example, the patella was fractured (transversely) in tension. The pins inserted through it resist any translational (shear) displacement and the malleable "tension band wire" pulls from the quadriceps tendon to the patellar tendon, compressing the fracture site and "relieving" the tension applied by the muscle force.



**Screws**: Screws are best at resisting tension (applying compression).

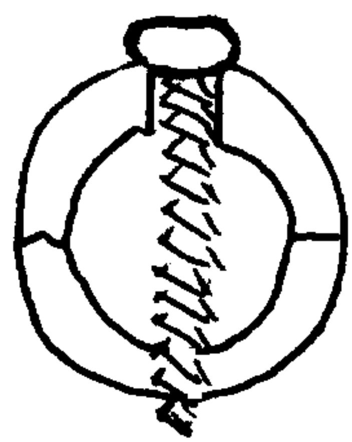
The threads pull whatever they are screwed into against the head. Thus the screw itself is loaded in tension and applies compression (just like the tension wires discussed above)



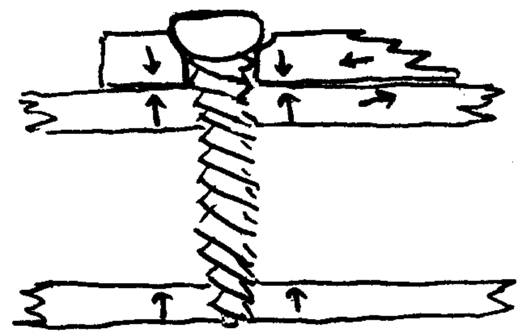


In this example
the midpoint of a spiral fracture is pulled back closed with a screw. The threads are in one side of the bone and the head pulls the other side of the bone to them. A screw which does this (pulls two fragments together) is called a "lag screw." At the hardware store "lag screws" are partially threaded screws like this one. In Orthopaedics, the first partially threaded screws were all designed with a cancellous thread (most still are) and so are frequently called "cancellous screws" rather than "lag screws.

A fully threaded screw like this one can still be used as a lag screw by "overdrilling" the near cortex (the one under the head) to the outer diameter of the screw so that the threads don't bite on that side.



A little thought will make you realize that plate screws are also lag screws. They are simply lagging the plate to the bone. Initially, when the screw is tight, it compresses the plate against the bone and friction prevents the plate from sliding around. Later, as the screw loosens from bone remodeling, the plate will slide and the screw can be loaded in a lot of shear at the plate bone interface – thus in nonunions you will often see the heads of screws sheared off as a failure mode for plating.



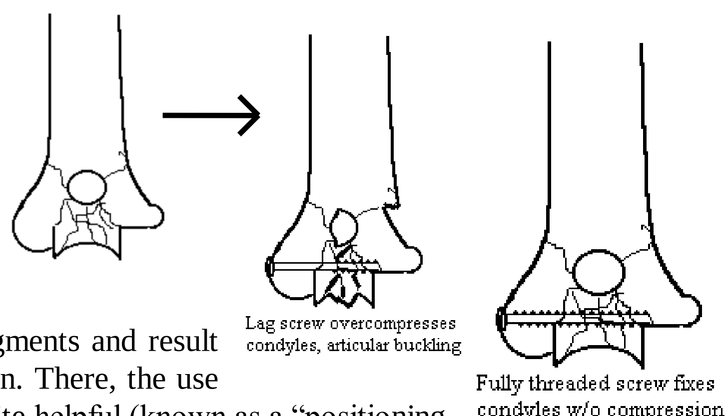
Screws as pins:

Screws can do the same job that pins do in resisting shear, acting as "threaded pins." They will only be as strong as a pin with the same diameter as the root diameter of the threads, however (not the outer diameter). Also realize that a smooth pin cannot hold two bone fragments apart ("distracted") while a threaded pin or fully threaded screw not only will hold fragments apart when used as a pin but has a tendency to push them apart as it crosses the fracture site (the threads in the near fragment screw it away from the far fragment during the moment or two before the threads catch in the distal fragment).

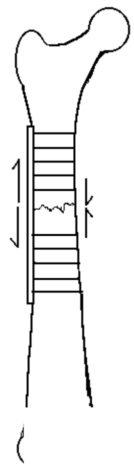
On the other hand, lag screws won't distract and can make excellent "pins" for fixation of cancellous fragments or as pins in the tension band wiring of the patella fracture above.

Screws used to distract fragments:

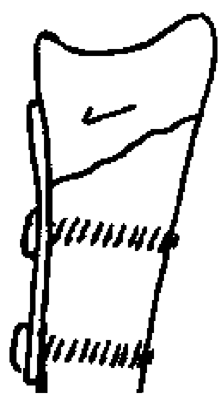
Occasionally, you *want* to hold two fragments apart, as in the distal humerus where the condyles can be split apart with so much comminution between them that when a compression screw is tightened it will extrude the comminuted central fragments and result in an overcompressed malreduction. There, the use of fully threaded screws can be quite helpful (known as a "positioning screw." In the situation shown it would be followed by plates up the medial and lateral columns to hold the condyles to the shaft.

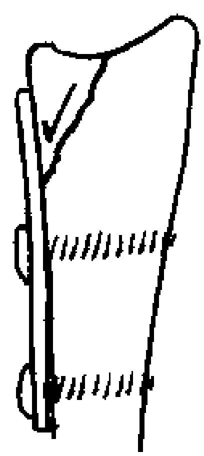


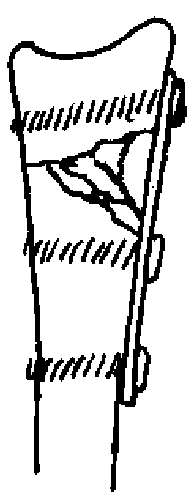

**Plates:** Plates are best at resisting tension (applying compression) also. Most plates, especially the semitubular and 1/3 tubular ones, are too thin to have much strength in bending. Some, such as the hip screw plates and distal femoral condylar plates have been thickened up enough to make them fairly strong in bending. Standard plates (often known as "compression plates") are best placed on the "tension side" of a bone with a simple fracture. For instance with a simple femur fracture the bone tends to go into varus under weight bearing loads. This applies compression to the medial cortex and, if the plate is placed on the lateral surface, loads the plate mostly in tension which it resists well.



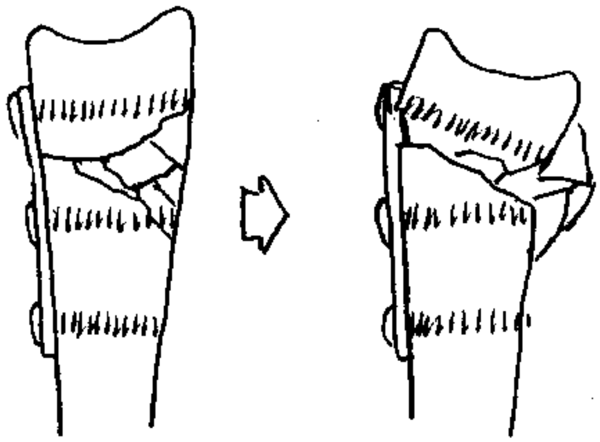
Buttress plates can be used as shown to resist shear in metaphyseal fractures as in these shear fractures of the distal radial metaphysis and of the volar lip. These plates are loaded in bending but the loads are not large and these cancellous bone fractures heal quickly before the plate fails.





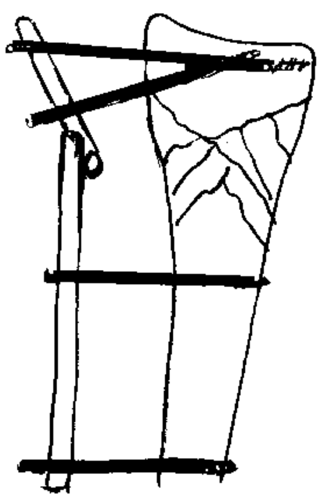


When buttress plates are placed on comminuted fractures as shown here they should be placed "across the comminution" not "across from the comminution."

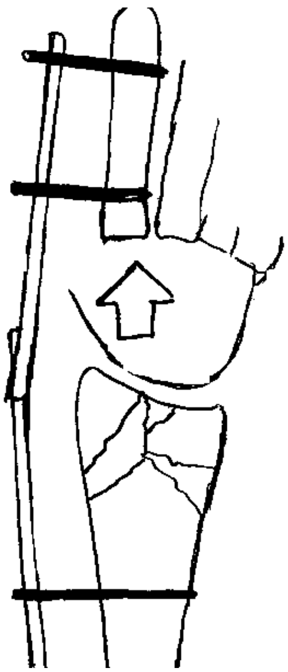


When placed "across from" comminution buttress plates are asked to do something they cannot really do. The far side of the bone will not hold its own length and the plate cannot, as the screws simply "toggle" in the plate allowing the opposites side of the bone to collapse. "Fixed angle" plates such as blade plates, compression hip screws and condylar screws are designed to prevent toggling in order to prevent this phenomenon.

**External Fixators:** Nowadays fixators are most often indicated to *apply* tension (resist compression) to fractures of the metaphysis or epiphysis. Metaphyseal fractures treated in this fashion include Colles fractures and proximal tibial metaphyseal fractures. Epiphyseal fractures include intraarticular fractures of the distal radius, bicondylar fractures of the tibial plateau treated with thin wire fixators and plafond fractures. These cancellous bone fractures are difficult to treat with IM nails as there isn't enough bone for the nail to bite in, and difficult to treat with plates as the comminuted bone doesn't hold well. However, they heal quickly, before fixator pins loosen and must be removed. In the past the most common indication for external fixation was the open diaphyseal fracture. Unfortunately, healing takes so long in the diaphysis that fixator pins generally loosen before healing is complete. Unreamed IM nails generally have the same infection rate as external fixators and mechanically are stronger, and so they usually will last long enough for those fractures to heal.

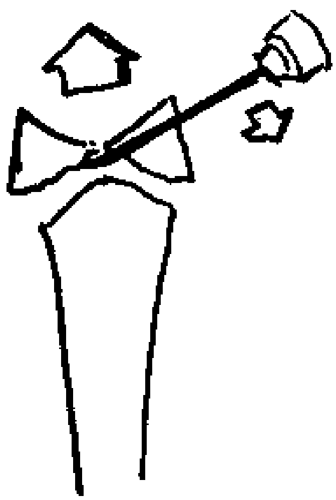


This is an example of a metaphyseal fracture treated with a fixator. When the epiphyseal block of bone is intact, it is generally better to place your pins in the epiphysis, rather than bridging (and thus immobilizing) a joint which could othrewise be mobilized. This also works well in the proximal tibia. When the epiphysis is broken many surgeons use "thin wire" fixators to avoid "bridging the joint".

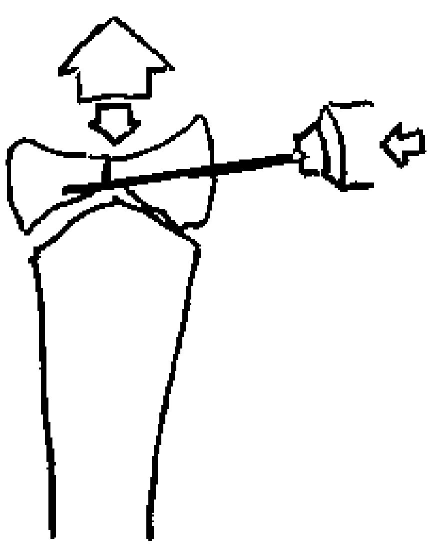


This is an example of a “joint bridging” ex fix where an epiphyseal (intraarticular) fracture of the distal radius is reduced by “ligamentotaxis” wherein the capsular ligaments pull the fragments back into fairly good alignment.

These fixators can be very helpful when your ORIF of the articular surface is tenuous -- as in a comminuted fracture (especially in osteoporotic bone) fixed with multiple screws and pins. When you fear that it is not stable enough and are considering putting the patient in a cast to try to protect your fixation, consider instead a bridging ex fix, not only for the wrist and ankle but also for the supracondylar/intracondylar fracture of the distal humerus and distal femur with wimpy fixation. A bridging ex fix will protect your ORIF much better than a cast!



Ligamentotaxis alone often results in an imperfect reduction, as seen here where the dorsal and volar ligaments of the distal radius have tilted the articular fragments. Inserting a subchondral pin gives you a handle with which to tilt that fragment. If inserted a little deep (as shown), when the near fragment is tilted the far fragment can also be tilted.



After the fragments are tilted to look good on fluoro the pin is inserted into the far fragment to hold that alignment. Once pinned, some of the tension may be released from the fixator to prevent slow healing from overdistraction

**Need more on** plates, intramedullary nails, and external fixators.