PLEASE CLICK ON THE FOLLOWING LINK TO WATCH THE LECTURE ONLONE :-

https://www.youtube.com/live/nD8-aG77ibU?si=STyyIO24xohWzl4r

IMPLANTS –SCREWS AND PLATE

A screw is a device which converts rotational forces into linear motion

Screws

SCREW - INTRODUCTION

- A device used to convert small applied rotational force into large compressive force.

- Helps in
  1. Holding plate or other prosthesis to the bone
  2. Fixing fracture fragments
  3. Achieving compression at fracture fragments.

Screws

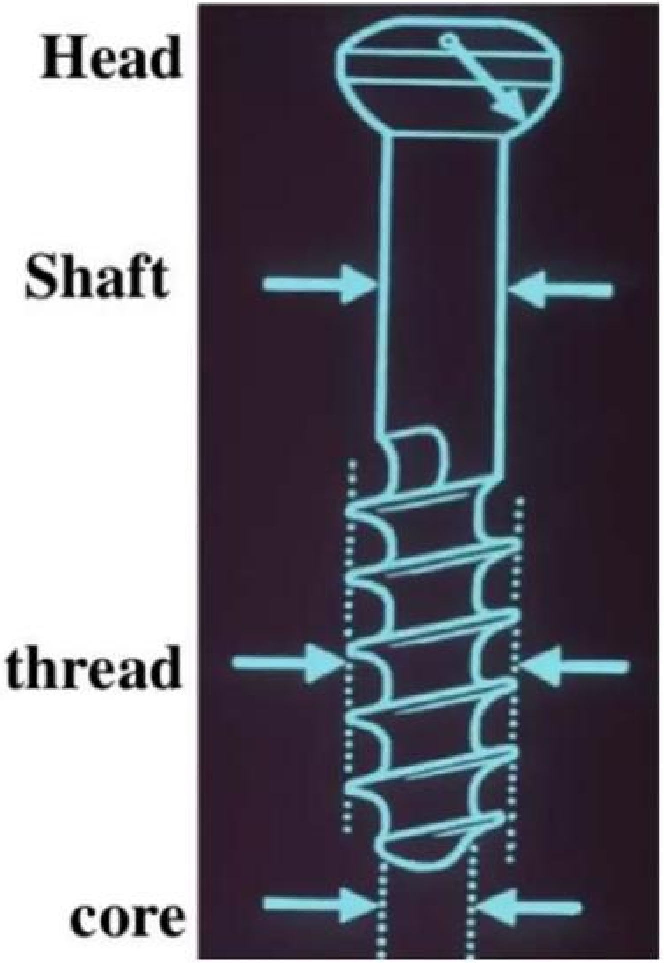
The two main thread types of surgical screws are for cortical bone and for cancellous bone.

Each screw type is available in fully threaded and partially threaded format.

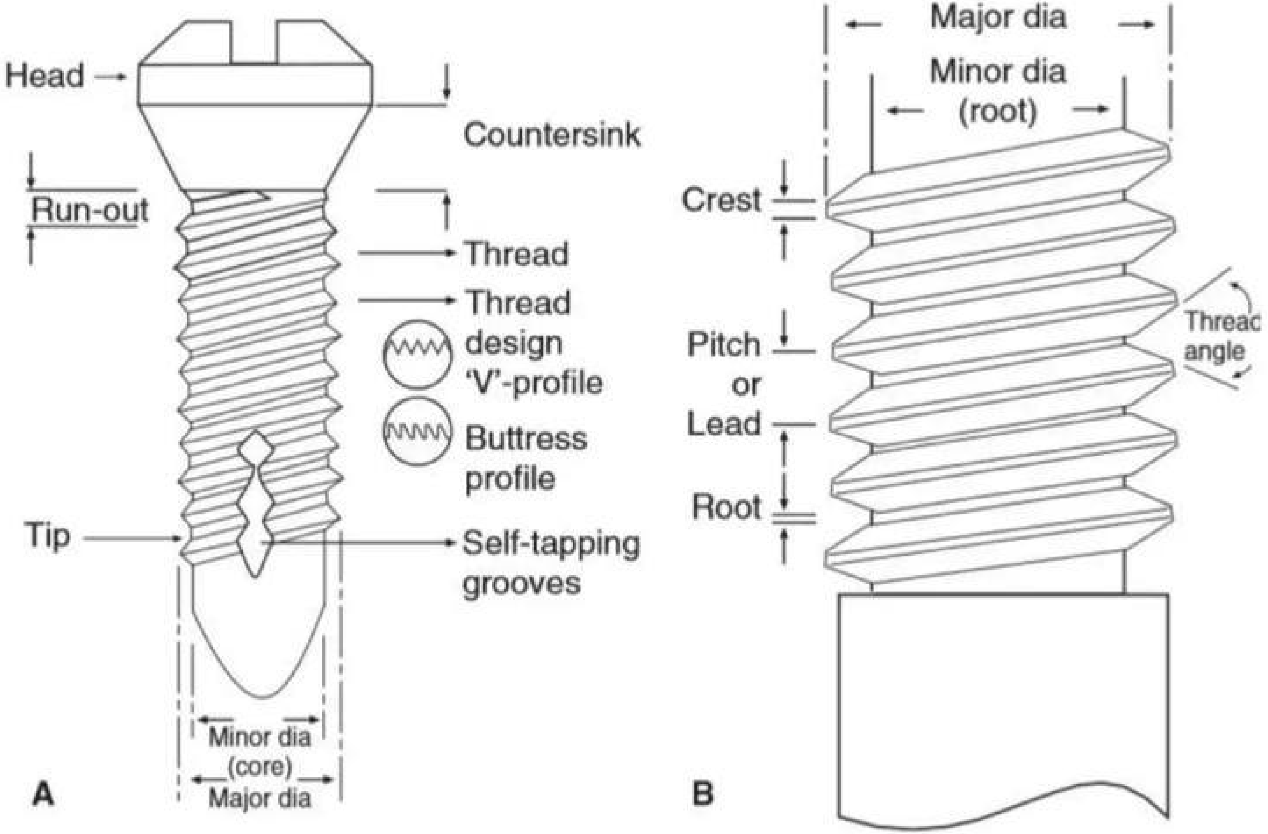
ANATOMY OF SCREW

- Four main parts:

  1. Head
  2. Shank/shaft
  3. Thread
  4. Tip

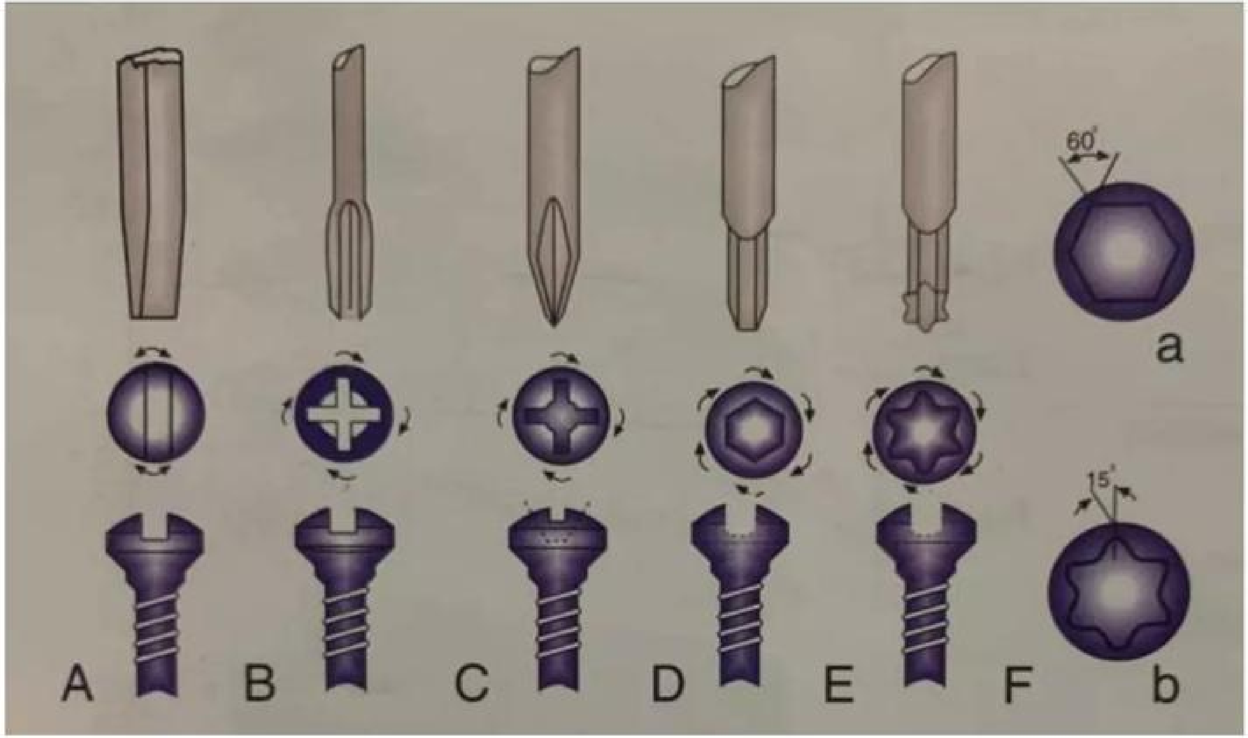


PARTS-
HEAD,SHAFT,THREAD,TIP

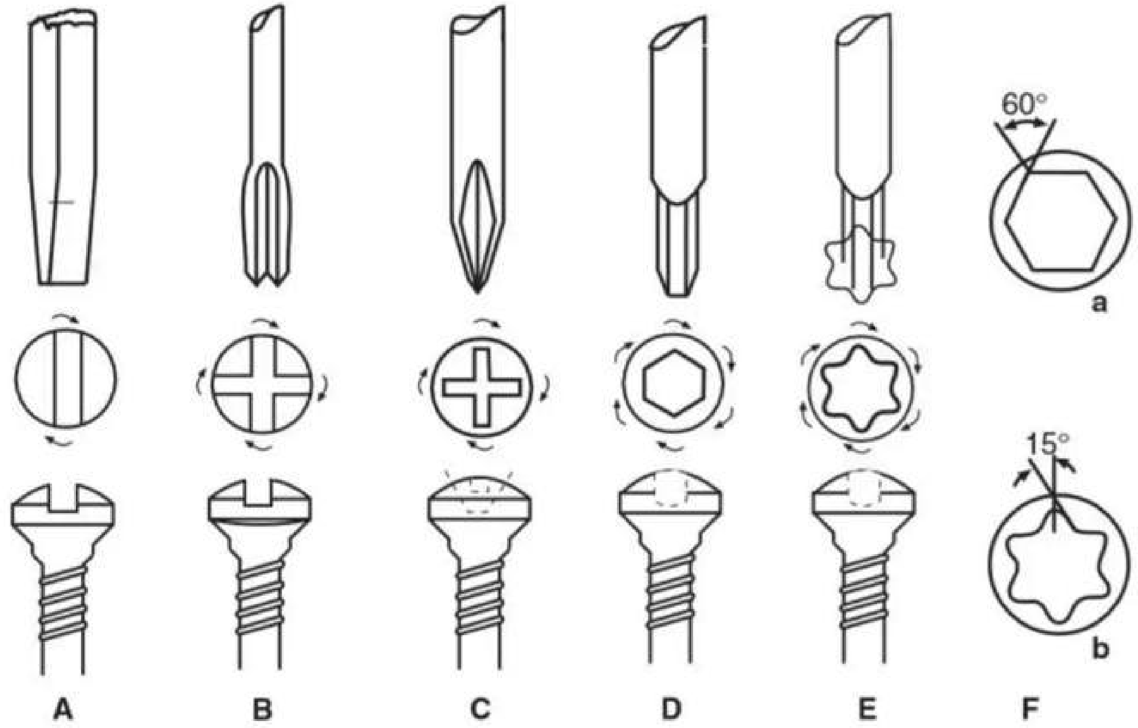


1. HEAD

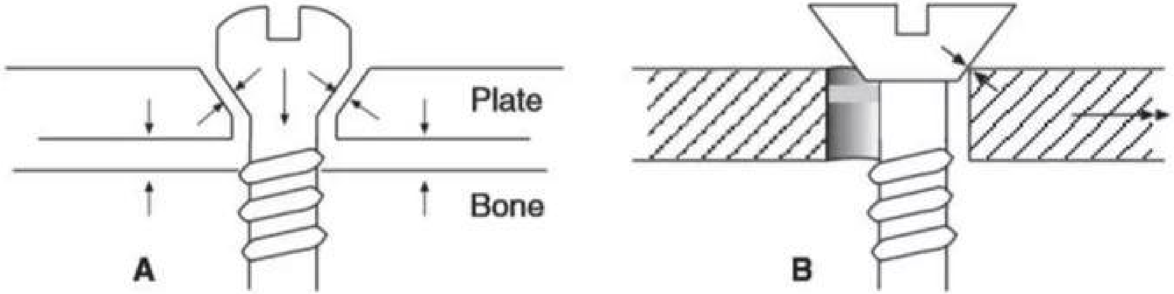
- Serves two functions –
  1. Provides the means for applying torque to the screw.
  2. It acts as a stop – translation force converts to compressive force.



- Recess – for firm purchase of screwdriver on the head for insertion and removal.


60°
a
15°
b
A
B
C
D
E
F

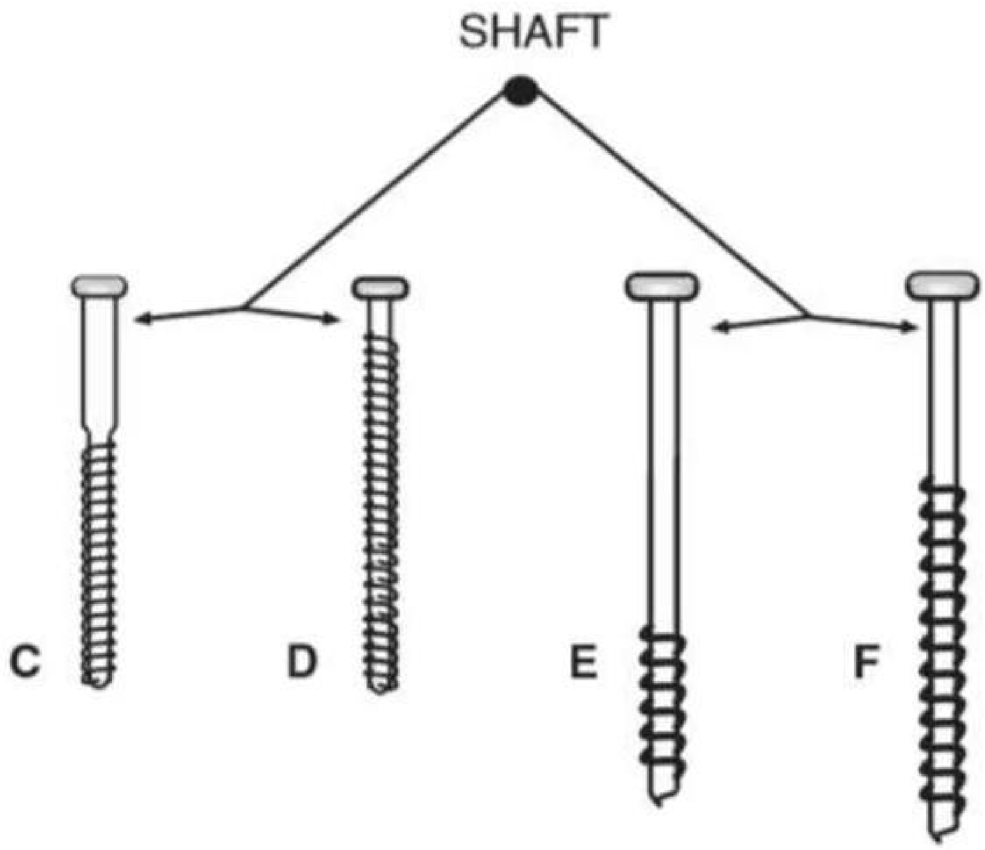
countersink



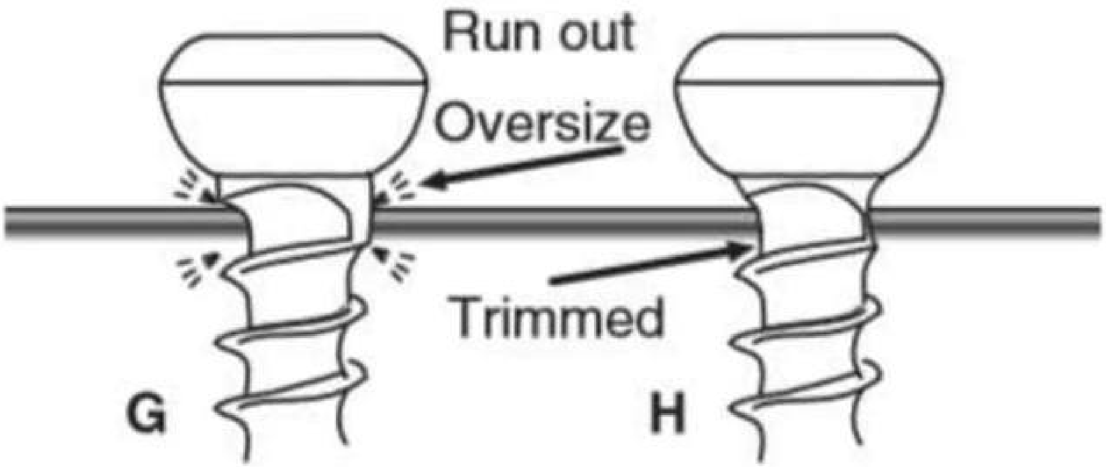
- Undersurface of head.
- Either-conical,hemispherical.

Shaft/shank

Smooth link between head and thread



Run out

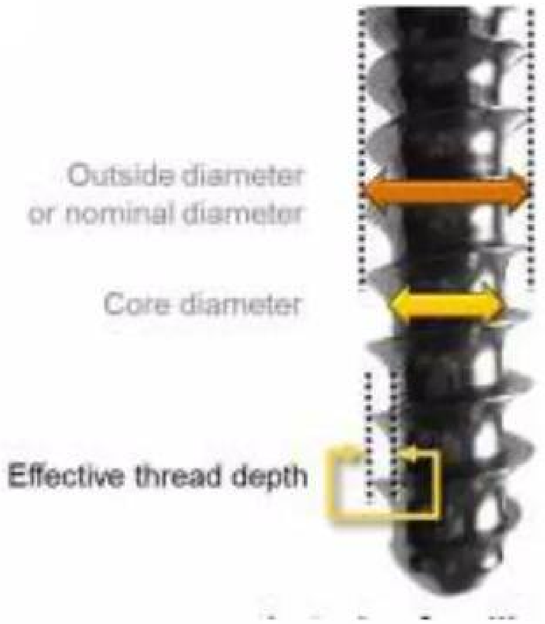


- the **run-out of a screw** refers to the transition zone between the fully threaded portion of the screw and the smooth (unthreaded) portion near the head. This area is critical because it can be a potential weak point where stress concentrations may lead to breakage under high loads.

  In biomechanical terms, screws with a poorly designed run -out may be more prone to **fatigue failure**, especially in load -bearing applications such as fracture fixation.

The tip

- Self tapping
- Non self tapping tap
- Cork screw tip
- Trocar tip
- Self drilling self tapping tip



Screws

Diameter

- Diameter of the core determines the minimal hole size for the screw to be accommodated in the bone and determines the drill used to create the pilot hole for the screw.

- In other words the drill to be used will be the same (approximately the same) diameter as the core of the screw.

Pitch

Distance between adjacent threads .

A cortical screw with affine thread has small pitch whereas cancellous screw with a coarse thread has a large pitch.

The stronger the bone the smaller the pitch and weaker the bone ,larger the pitch.

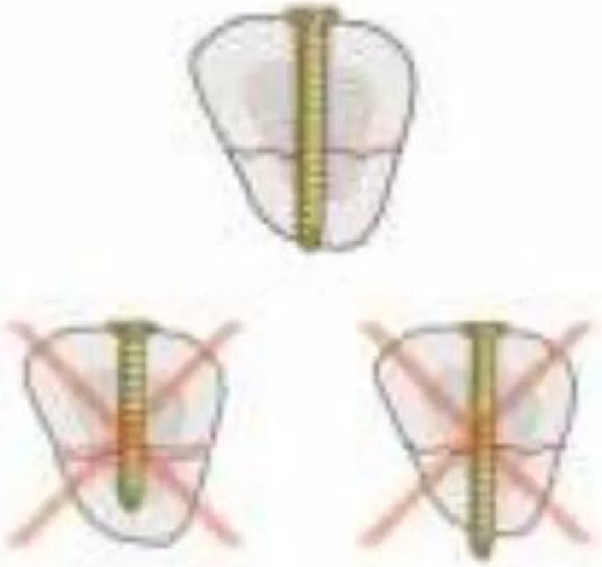
Cortical -1.75 mm

Cancellous-2.75 mm

Screw

Length

- The nominal length of the screw is from the top of the head to the screw tip.
- An appropriate length of screw needs to be chosen.

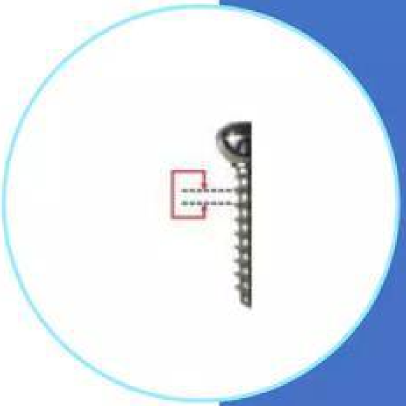


Screws

- *Too short* - it will not gain full purchase in the bone.

- *Too long* - it may cause problems by irritating the soft tissues, or protruding subcutaneously.

Screws



Pitch

- The pitch of the screw is the length travelled by the screw with each 360° turn of the spiral.

Screws

- Cortical bone screws have a smaller pitch, and a shallower thread depth (to grip dense cortical bone).

- Cancellous bone screws have a larger pitch, and deeper thread depth (to gain better purchase in the softer, porous cancellous bone).

Screws

Pitch

- *distance between threads*

Lead

- *distance advanced with one revolution*

Screw working distance (length)

- *defined as the length of bone traversed by the screw*

Outer diameter-diameter across the maximum thread width

.

Root (inner) diameter

Types of screws:

Desirable qualities of screws

- Easy to insert and remove
- Good purchase on the bone
- Strong to withstand tensile, torsional and shearing stresses during use and application

Types of screws

Cortical screws

- The threads are smaller (in diameter) and are closely placed (lower pitch).
- smaller pitch increases the holding power of the screw.
- The modulus of elasticity screw is more than 10 times that of bone; therefore, much of the elastic deformation occurs in the bone.

Cancellous screws

- Its tip is not tapered.
- It has larger threads and a higher pitch as compared to the cortical screw.
- An increase in the thread diameter of a cancellous screw increases its pull-out strength.
- The spring reaction comes from the cancellous bone as it is deformed during the thread forming process.

Self tapping screw

- Refers to a screw which is inserted directly into a pre-drilled hole without first tapping a thread.
- Self-tapping screw may further be subdivided into thread-forming and thread-cutting screws. The thread-forming type moulds (i.e. forms) its own elastic-plastic deformation or by local destruction of the bone. The thread-cutting screw cuts its threads through the bone over which it advances.
- The cancellous bone screw is a thread-forming, self-tapping screw. The screw thread forms its own mating bone thread by compressing the soft cancellous bone.

Feature	**Thread-Forming**	**Thread-Cutting**
Action	Compresses & displaces bone	Cuts & removes bone
Insertion Torque	Higher (more force needed)	Lower (easier insertion)
Bone Type	Best for cancellous bone	Best for cortical bone
Holding Strength	Higher (bone is compressed)	Slightly lower (bone is cut away)

CANNULATED SCREW

- Precise insertion in metaphyseal or epiphyseal site over a guide wire reducing the problem of having to remove and reposition an incorrectly placed screw.
- A guide wire accurately visualizes the path of the screw. If guide wire position must be changed, it can be done without enlarging the hole and sacrificing purchase strength of the bone. Final placement of the screw requires use of cannulated drill and occasional use of a cannulated tap. The screwdriver is also cannulated. Cancellous cannulated screws come in large and small sizes.

FULLY AND PARTIALLY THREADED SCREWS

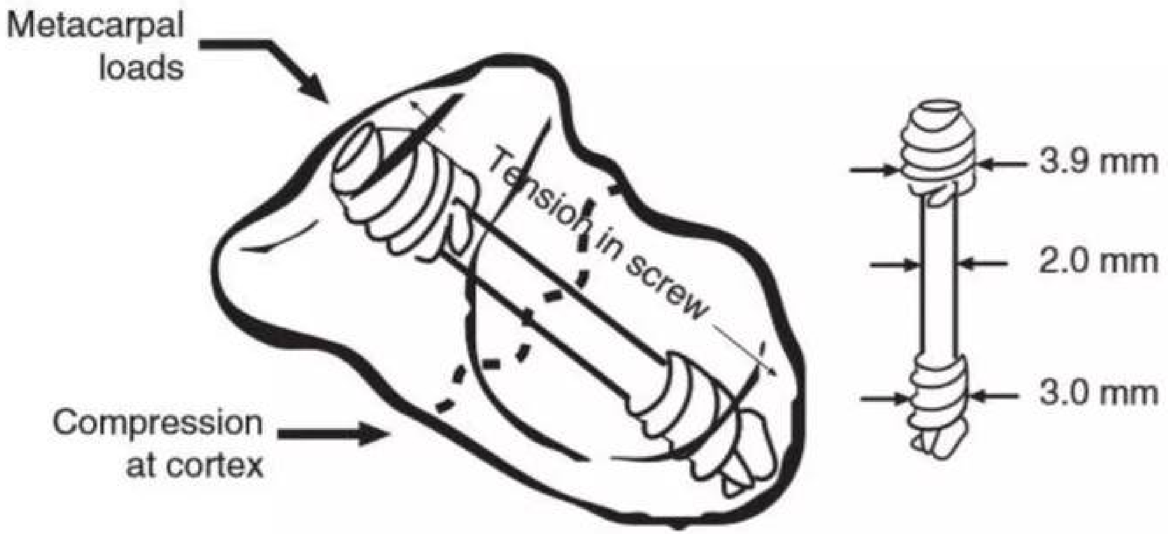
- A fully threaded cortical screw can function as lag screw only when the near cortex is over-drilled. A fully threaded cortical screw may be self-tapping or non-self-tapping.
- A partially threaded cortical screw is called a shaft screw. The shaft diameter corresponds to the outer diameter of the thread. This screw has better strength and stiffness than a fully threaded screw which is an advantage when it is used as a lag screw and as an axial compression screw. It is a non-self-tapping screw

NON SELF TAPPING SCREW

- A non-self-tapping screw allows precision placement in hard cortical bone, particularly if one is trying to insert a screw obliquely into the bone to lag two bone fragments together.
- The NST screw is incapable of cutting a channel in cortical bone and can be removed and reinserted without the fear of inadvertent damage.

HERBERT SCREW

- For interfragmentary compression.
- no head and threads are present at both ends of the screw, with a pitch differential between the leading and trailing threads. intention is for the screw to be buried beneath a bony surface.



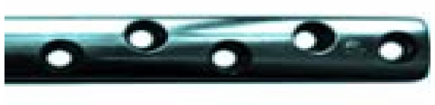
PLATES

Historical introduction

Plates for fixation of long bone fractures were first recorded by Hansmann, of Heidelberg University, Germany in 1886. One of his original plate sets is seen below. Already then the instruments where listed. The white label says: Attention! Do not lose anything.

Plates – form

Plates are now widely accepted with different standard techniques of osteosynthesis, throughout the skeleton. Different anatomical locations demand different shapes and sizes of plates.



Since 1958, AO has devised a family of plates for long bone fractures, starting with a round-holed plate (to be used with an external compression device).

Dynamic compression plates

In 1969 the Dynamic Compression Plate (DCP) was developed.

The DCP has a self-compressing hole design which is described later.

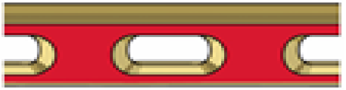
Experimental work showed that the flat undersurface of the DCP interfered with the blood supply of the underlying cortex onto which it was compressed by the screws.

The concept of the "footprint" of a plate emerged. The "footprint" is the area of the undersurface of the plate in contact with the underlying bony cortex.

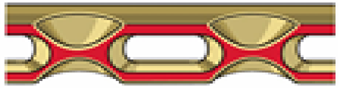
Limited Contact Dynamic Compression plates

The need to preserve the blood supply of the underlying cortex led to considerations of reducing the footprints of plates, and the Limited Contact Dynamic Compression Plate (LC DCP) (1994) was created. The LC DCP has a fluted undersurface.

Footprint of a DCP



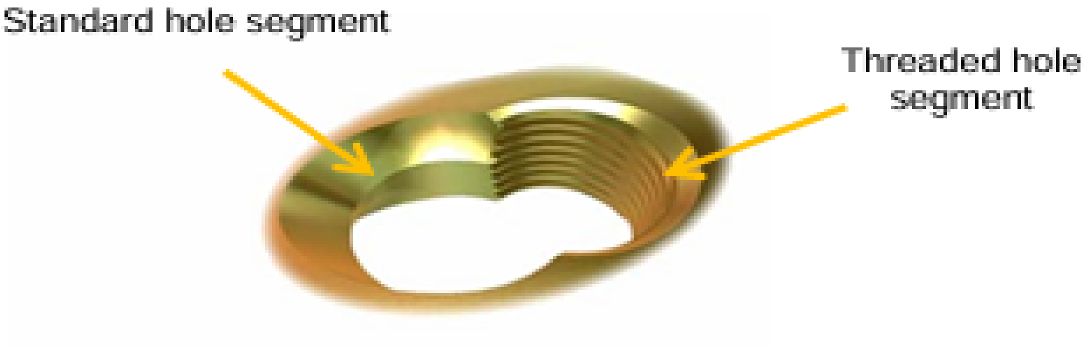
Footprint of an LC DCP



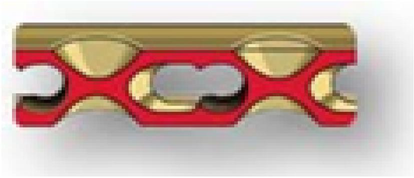
Locking compression plates

Since 2001 the Locking Compression Plate (LCP), with combination holes has come into use.

The LCP has a combi hole which permits the insertion of standard head screws and of threaded locking head screws.



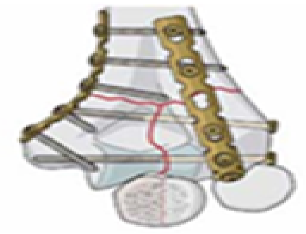
This means that the LCP can be used for conventional plating functions, and also with locking head screws to produce angular stability.



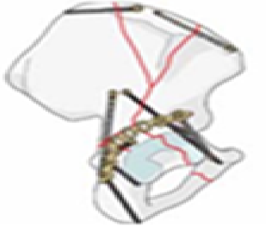
The LCP is also designed with a minimal footprint.

Reconstruction plates

Reconstruction plates have notched edges to permit bending "on the flat" as well as conventional bending. These plates are very adaptable, using the correct tools, ...

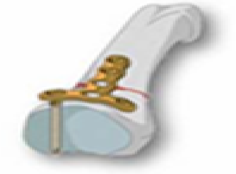


...and are useful in complex anatomical sites, such as the distal humerus, the pelvis, the clavicle, etc.

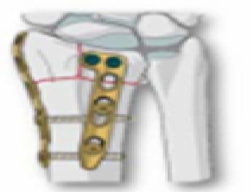


Anatomical plates

Here are some examples of other anatomically preformed plates:



T-plate for phalanges

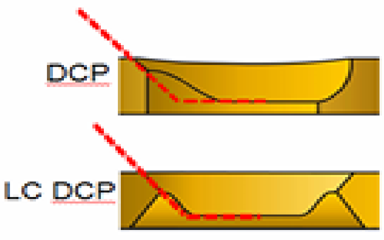


L and LCP contoured plates for distal radius

Ulna plates and distal humerus plates

Plates – holes

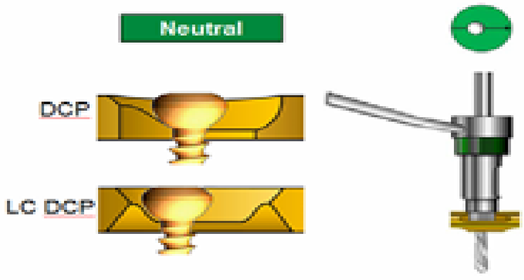
Dynamic compression plates are designed with screw holes of a particular form.
The holes are oblong and the portion of each hole distant from the fracture has a sloping form or "shoulder".



Note that the DCP and LC DCP have different forms.

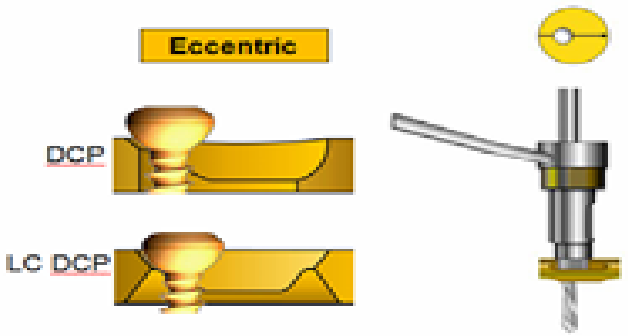
Screw insertion – neutral position

A screw can be inserted in any DCP hole in a neutral position. No relative motion is created between the plate and the screw on tightening. A special neutral drill guide – colored green – is used.



Screw insertion – eccentric position

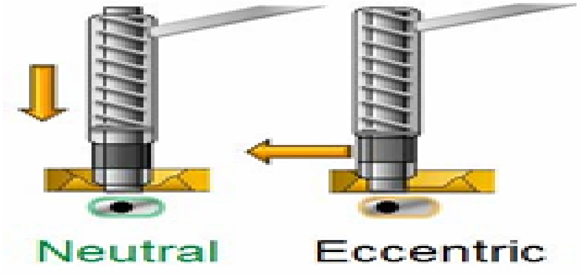
A screw can be inserted in any DCP hole in an eccentric position in order to get compression at the fracture site when tightening.
Special load drill guides – colored yellow – are used to position the drill bit eccentrically.



Important: DCP and LC DCP guides are different. They cannot be mixed up!

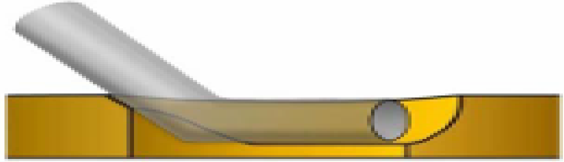
Spring-loaded universal drill guide

There is also a spring-loaded universal drill guide, which can be used for insertion of conventional screws through all plates (but not for the locking head screws), and which can serve both functions: if the barrel is depressed toward the plate, the end of the barrel slides down the slope of the plate hole and takes up a neutral relationship.



If there is no downward pressure on the barrel but it is drawn to the edge of the plate hole away from the fracture, an eccentric load hole can be drilled.

DCP principle



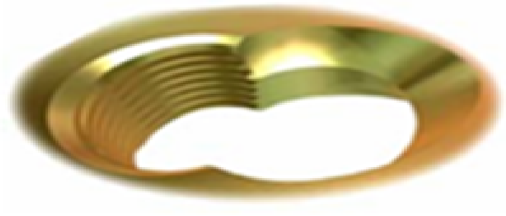
The sloping shoulder of the DCP hole has the form of part of an angled cylinder

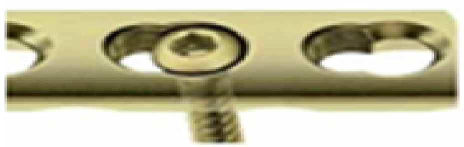
If a screw is inserted eccentrically…

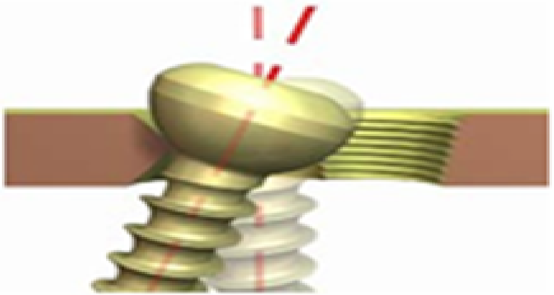
… so that its head, on final tightening, slides down the sloping profile of the hole, the screw/bone unit will be shifted toward the fracture and the fracture plane will thereby be compressed.

LCP

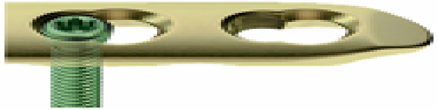
The combination hole of the LCP accepts conventional screws for conventional plating techniques, but also accepts locking head screws to create angularly stable fixations.

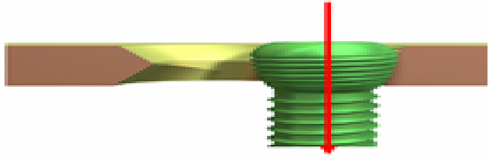




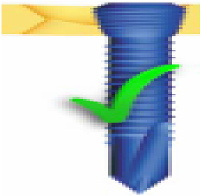


Conventional screws can be tilted in the non-threaded portions of the combination holes.

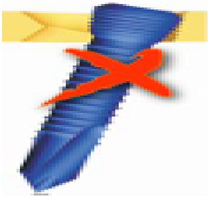




Locking head screws must not be angled in the threaded portions of the holes.

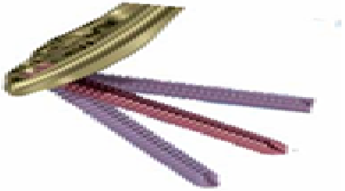


Locking head screws must be inserted carefully: The threads of the screw and the plate must match. Optimal angular stability is gained when the screw is inserted at 90° to the plate, using a special guide. Hence, the importance of the correct use of the LCP drill guide.



Angular stability is greatly reduced if the LHS is not inserted at 90°.

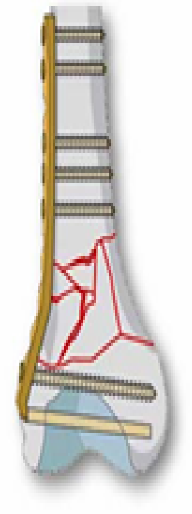
There are some exceptions.
Some locking plates have threaded holes that are designed to permit a small range of angulation of the screw until it is tightened and then locks home.
A distal radial variable-angle locking plate is illustrated.

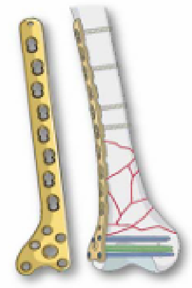


Plates providing angular stability

Prior to the introduction of locking plate technology, angular stability, especially for the management of metaphyseal fractures, was achieved by the use of fixed angle devices. The 95° angled blade plate, illustrated here, is one such implant.

A high level of surgical experience is required to use these devices correctly. These are still the implants of choice for many femoral osteotomies.





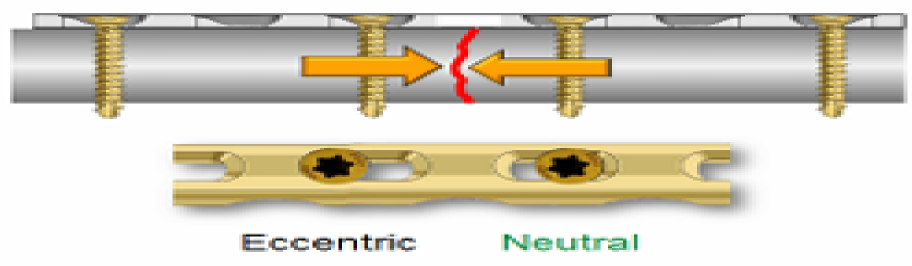
Screws that lock into threaded plate holes now provide an alternative method of achieving angular stability, as illustrated here.
Because the screws in the metaphyseal fragment purchase in the bone, and also lock into the plate holes, the mechanical equivalent of a fixed angle device can be constructed.

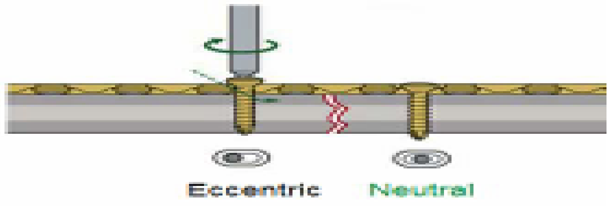
One great advantage is that locking plate/screw systems are more stable in the osteoporotic bone of the elderly.

Plates – functions

Compression

Compressing together the main fragments of a single plane fracture can result in absolute stability, that is, the complete abolition of interfragmentary movement. Interfragmentary compression in single plane, diaphyseal fractures, can be achieved by exploiting the eccentric loading capabilities of the dynamic compression family of plates.

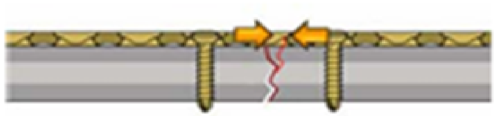


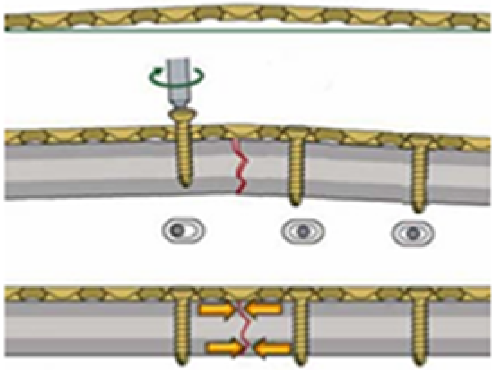


In this diagram, the plate is fixed to the right-hand fragment with a screw inserted in a neutral mode.
A screw is then inserted into the left-hand fragment in an eccentric (load) mode.

As the load screw is fully inserted, it engages and slides down the sloping surface of the plate hole, and the screw and bone move toward the fracture, compressing it.

If the plate that will exert axial compression is exactly contoured to the anatomically reduced fracture surface, there will be some gapping of the opposite cortex when the plate is tensioned by tightening the load screw. This is due to the compression's being maximal immediately beneath the plate, and not evenly distributed over the whole area of the fracture plane.





The solution to this problem is to "overbend" the plate so that its center stands off 1–2 mm from the anatomically reduced fracture surface.

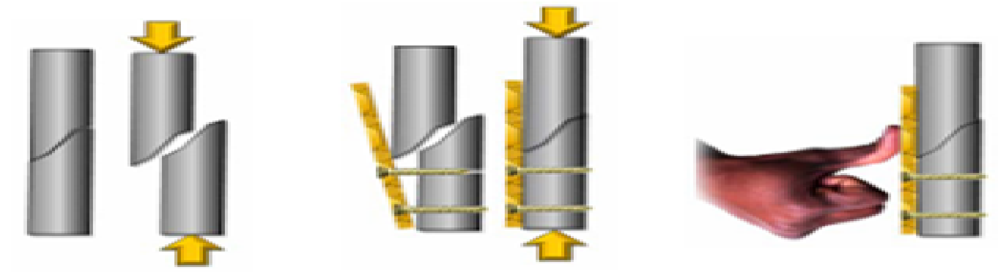
When the neutral side of the plate is applied to the bone, slight gapping of the cortex will occur directly underneath the plate.

As the load screw is tightened, the tension generated in the plate compresses the fracture evenly across the full diameter of the bone.

Neutralization

A primary lag screw fixation, exerting interfragmentary compression, can be vulnerable to disruption by physiological bending and/or rotational forces.
Such a primary fixation is usually protected by the use of a plate, spanning from one main fragment to the other – this "neutralizes" the disruptive forces.
All such forces are then transmitted via the plate, and by-pass the primary lag screw fixation.
On the left, a long spiral fracture has been treated by interfragmentary compression using two lag screws. The vulnerable screw fixation has been protected by a spanning plate. The plate does not apply axial compression – all the plate screws are inserted in neutral mode.
Above is an example of a 1/3 tubular plate protecting the lag screw fixation of the distal fibula in an ankle injury.

Buttressing



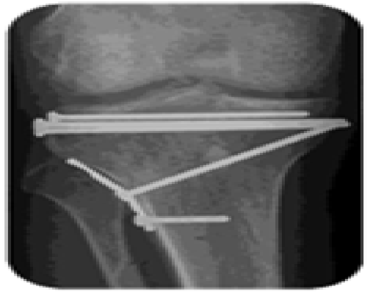
(1) (2) (3)

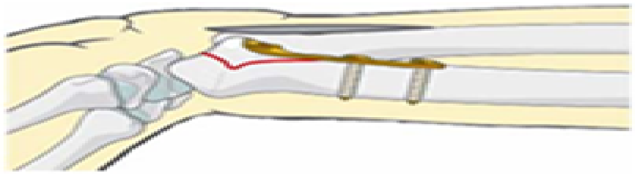
(1) Many fractures tend to shorten and displace under axial load.

(2) Such a fracture can be stabilized by applying a plate to one main fragment in such a manner that it buttresses the other fragment, so as to prevent displacement.

(3) The buttressing plate acts like a thumb that is pressing the other fragment into a reduced position.

Here are two examples of a buttressing plate holding reduced a tibia head and an anterior marginal distal radial fracture (Barton's fracture).





Examples of indications:
- Tibial head fracture
- Distal radius fracture

Bridging

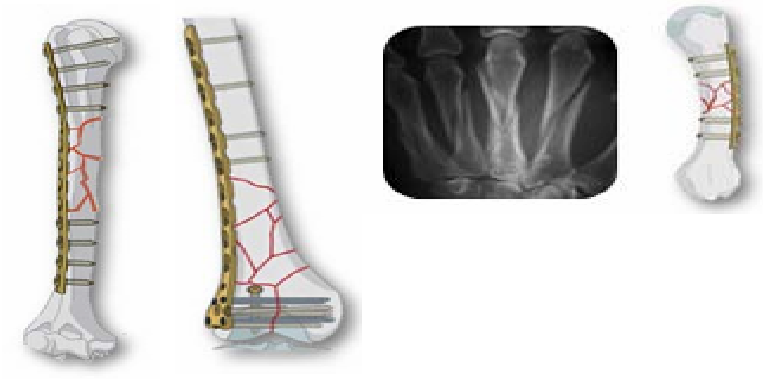
In comminuted diaphyseal fractures, a plate is often applied, spanning the multifragmentary zone, and attached only to the main fragments. It is used to restore length, axial alignment, and rotational alignment.

This preserves the biology of the multifragmentary zone, which heals by external and interfragmentary callus.

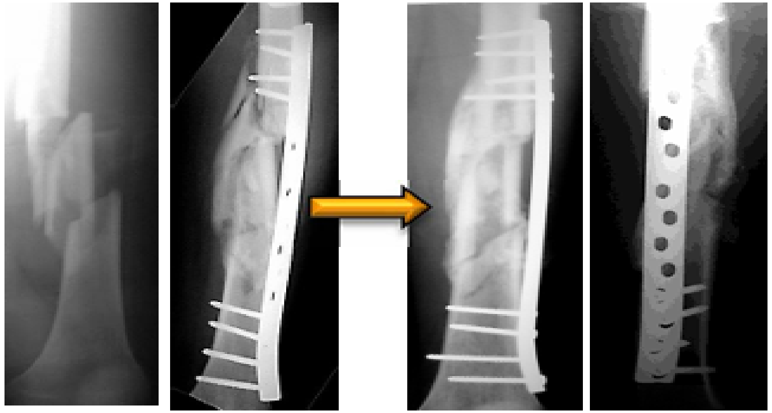
Some examples

Here are three examples:

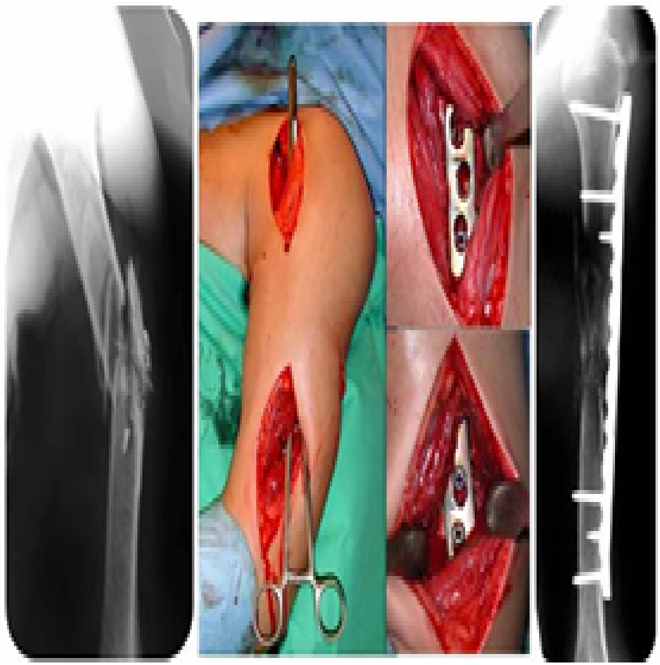
- Humerus
- Distal femur
- Phalanges



This comminuted femoral shaft fracture was bridged with a plate. After 9 months, healing by callus formation is evident on x-ray.

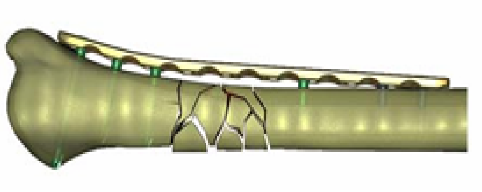


Bridge plating can be performed by either an open technique, or minimally invasively.
In this example, with minimally invasive surgery (MIS), the plate was applied to bridge this gunshot injury.



Case: C. Sommer

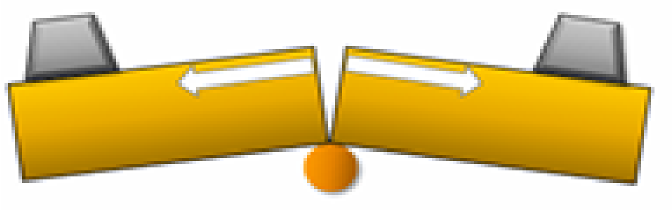
Next is an illustration of the LCP used as an "internal fixator" to bridge a multifragmentary diaphyseal fracture complex.
As locking head screws are used, the plate does not need to be contoured exactly to the bone, the cortical vascularity is not compromised as the plate stands off the bone, and there is angular stability in the metaphyseal zone.



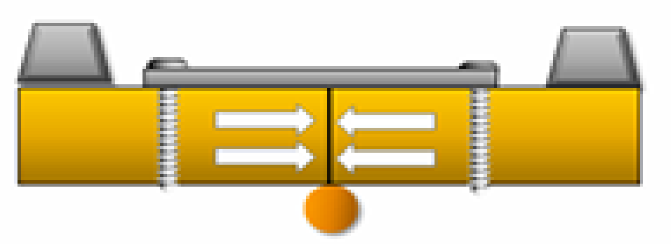
The next example shows an LCP used with conventional screws as a traditional plate.
The fixation is less stable due to the lack of angular stability with conventional screws.
The position is maintained by compressing the contoured plate to the bone surface.

Tension band

If a body with a fracture is loaded at each end, over a bending point (fulcrum), tension (distraction) forces are generated, maximal on the side opposite the fulcrum, and angulation occurs.

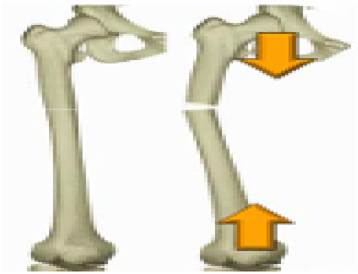


However, if an inelastic band, such as a plate, is anchored to the tension side of the body, the same load will generate compression across the fracture interface.

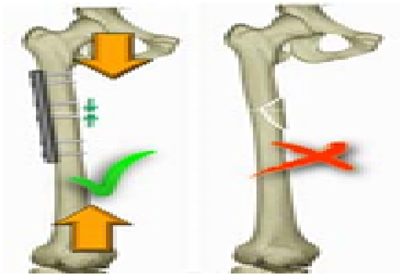


This is known as the tension band principle.

Some examples

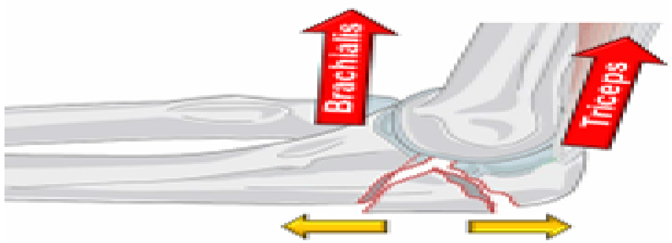


The femur is an eccentrically loaded bone. When axially loaded, the lateral cortex is under tension and the medial cortex bears compressive forces.



A plate fixed to the lateral cortex will function as a tension band and the eccentric physiological load will cause compressive forces in the medial cortex.
If the medial cortex is fragmented and cannot resist compressive forces, a tension band fixation will not prevent plate bending and angulation.

In this olecranon fracture, the pull of the triceps and brachialis muscles would tend to distract the fracture complex.



The plate, on the tension aspect of the ulna, converts that tension into compression at the fracture interfaces.
The plate is functioning as a tension band.