

Plates—Form and function

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Learning outcomes

- At the end of this lecture you will be able to:
 - Outline the evolution of plates
 - Describe the function of compression holes
 - List different functions of plates

AO

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- Outline the evolution of plates
- Describe the function of compression holes
- List different functions of plates

Historical introduction



- First record of plates for long bones:
 - 1886 by Hansmann, Germany
- Original plate set



AO

- Plates for fixation of long-bone fractures were first recorded by Hansmann, Heidelberg University, Germany, in 1886.
- One of his original plate sets is seen below
- White label says: Attention! Do not lose anything
- Instruments were listed in set.

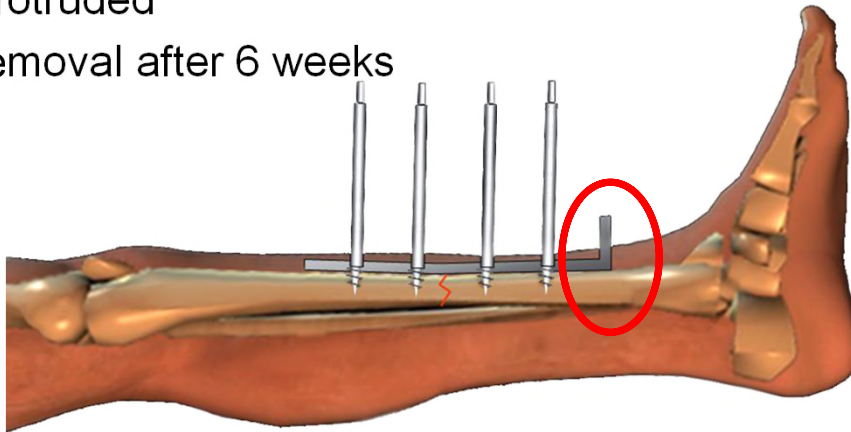
Additional Material

The next five slides are additional to the core knowledge, but may be incorporated in any presentation where they are deemed to be required.

AO

Historical introduction

- Plates made of “German silver”
 - were bent up at one end
- Screws protruded
- Implant removal after 6 weeks



AO

Hansmann's plates were of “German silver” and were bent up at one end to protrude (stick out) through the integuments (skin).

The long shanked screws also protruded.

The implants were removed at about 6 weeks and external splintage was then applied.

Historical introduction

- Introduction of stable plating to allow early motion
 - 1940 by G Perkins, London

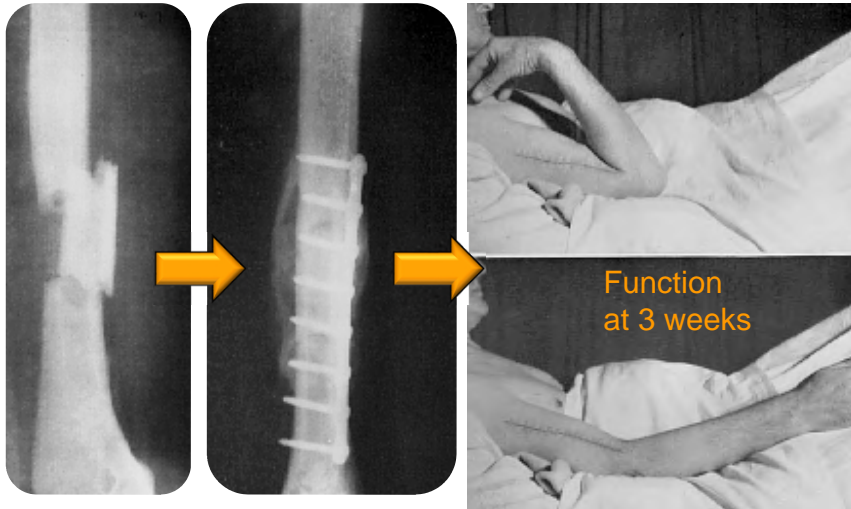


AO

Professor George Perkins, London, UK, was one of the first, in the 1940s, to stress the advantage of stable plating in order to allow for early motion.

Historical introduction

- Introduction of stable plating to allow early motion
 - 1940 by G Perkins, London

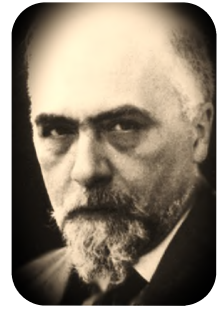


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This segmental humeral fracture was plated by Perkins and the patient started functional rehabilitation early after operation.

Historical introduction

- Introduction of compression plating
 - 1949 by Robert Danis, Belgium

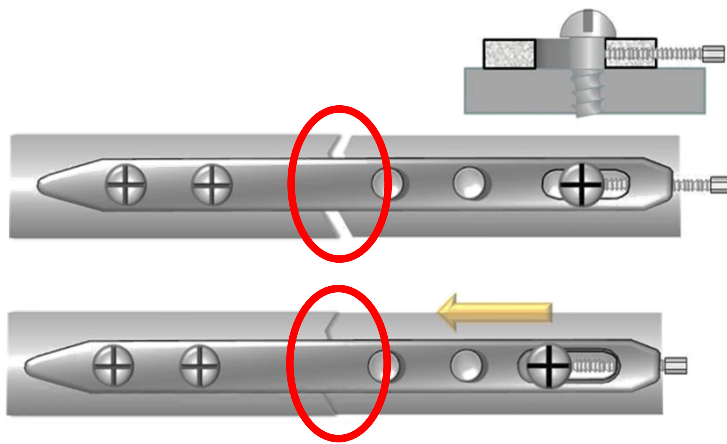
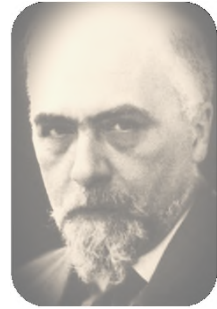


AO

Robert Danis (Belgium) introduced compression plating in 1949.

Historical introduction

- Design of “coapteur”
 - to apply axial compression



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This device was constructed to allow axial compression of the fracture site.

Plates—forms: evolution

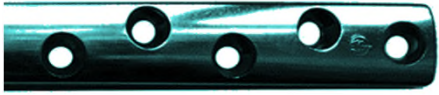
- Used as standard technique of osteosynthesis throughout the skeleton
- Applied to different anatomical locations
 - different shapes
 - different sizes of plates

AO

Plates are now widely accepted with different standard techniques of osteosynthesis throughout the skeleton.

Different anatomical locations demand different shapes and sizes of plates.

Plates—forms: evolution

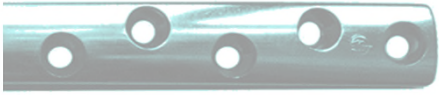


- Round hole plate 1960

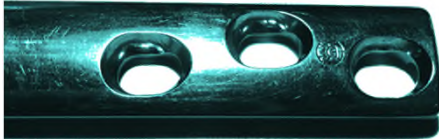
AO

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), then the dynamic compression plate (DCP).

Plates—forms: evolution



- Round hole plate 1960



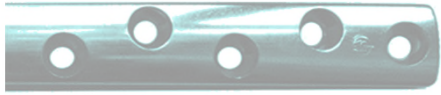
- DCP 1969



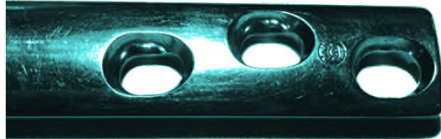
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The DCP has a self-compressing hole design, which we shall consider in detail later.

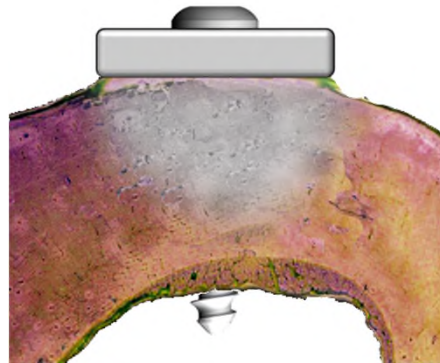
Plates—forms: evolution



- Round hole plate 1960



- DCP 1969

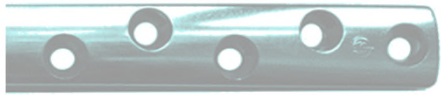


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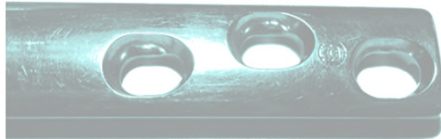
Experimental work showed that the flat undersurface of the DCP interfered with the blood supply of the underlying cortex onto which it was compressed by the screws.

The concept of the “footprint” of a plate emerged—that area of the undersurface of the plate in contact with the underlying bony cortex.

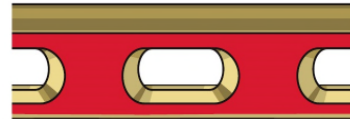
Plates—forms: evolution



- Round hole plate 1960



- DCP 1969



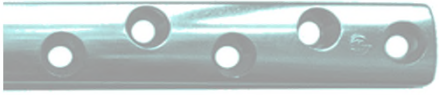
- LC DCP 1994
- “footprint”



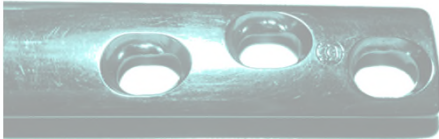
AO

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) was created. Note its fluted undersurface. Note the difference—the red color on undersurface indicates the size of footprint on the underlying bone.

Plates—forms: evolution



- Round hole plate 1960



- DCP 1969



- LC DCP 1994



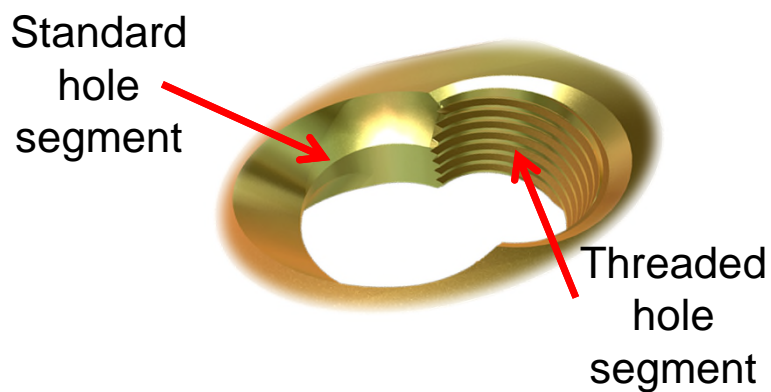
- LCP 2001

AO

Latterly, since 2001 the locking compression plate (LCP) with combination holes has come into use.

Plates—forms: LCP

- Features of LCP
 - Combi hole:
 - Locking head screws (LHS)
 - Conventional screws



AO

The holes permit 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.

Plates—forms: LCP

- Features of LCP
 - Combi hole
 - Locking head screws (LHS)
 - Conventional screws
 - Minimal footprint



AO

The LCP is also designed with a minimal footprint.

Plates—forms: reconstruction

- Reconstruction plates
 - Have notched edges
 - Can be bent in multiple planes



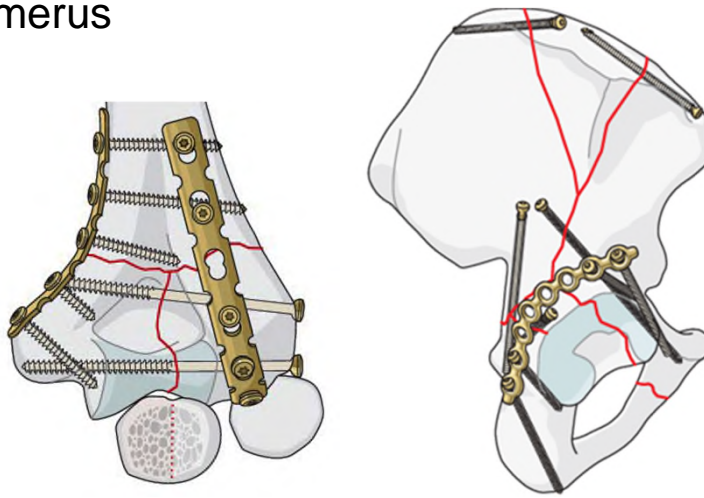
AO

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, ...

Plates—forms: reconstruction

- Reconstruction plates
 - Distal humerus
 - Pelvis

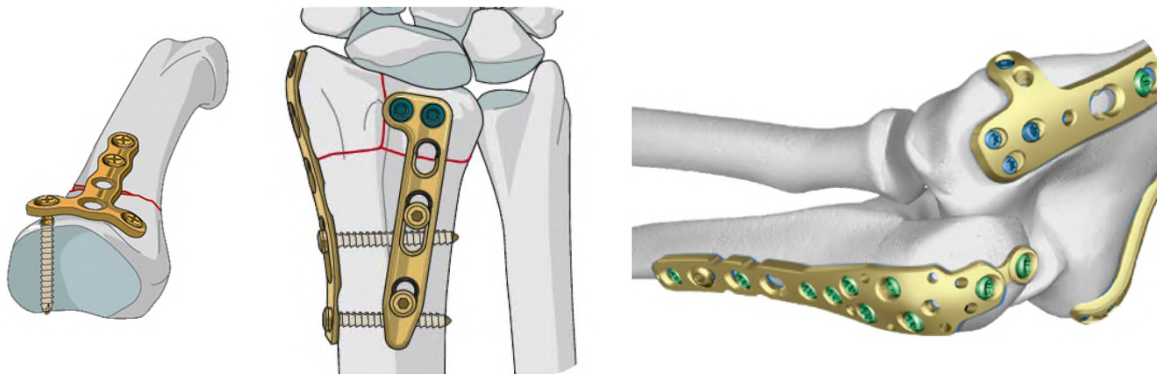


AO

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

Plates—forms: anatomical plates

- Anatomically preformed plates (Examples)
 - T-plate for phalanges
 - L- and straight-contoured plates for distal radius
 - Ulna plates and distal humerus plates



AO

Here are some examples of other anatomically preformed plates:

- T-plate for phalanges
- L and LCP contoured plate for distal radius
- Ulna plates and distal humerus plates

Plates—holes: DCP principle



- Oval shape

AO

Dynamic compression plates are designed with screw holes of a particular form, as illustrated.

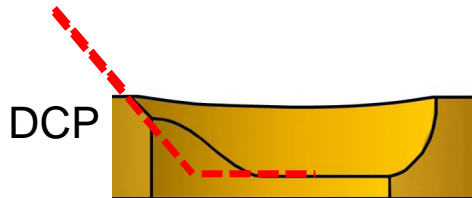
The holes are oblong and the portion of each hole distant from the fracture has a sloping form.

Plates—holes: DCP principle

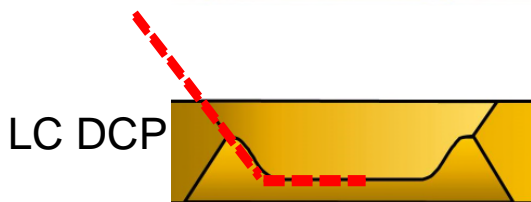


- Oval shape

- “Sloping form”



DCP



LC DCP

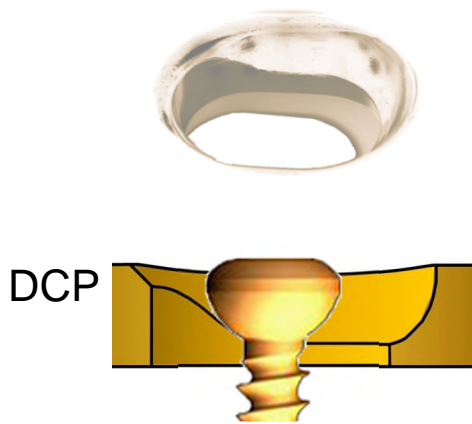
AO

Dynamic compression plates are designed with screw holes of a particular form, as illustrated.

The holes are oblong and the portion of each hole distant from the fracture has a sloping form, or “shoulder.”

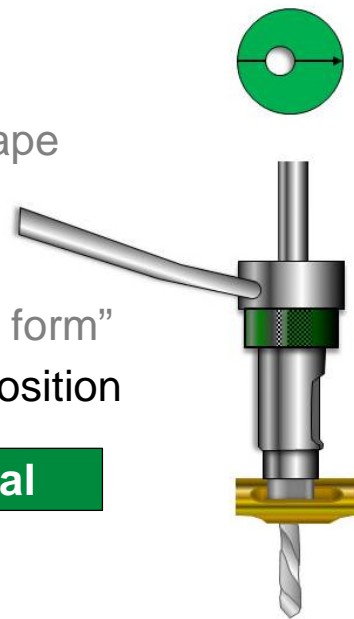
Note that the DCP and LC DCP have different forms.

Plates—holes: DCP principle



- Oval shape
- “Sloping form”
- Screw position

Neutral

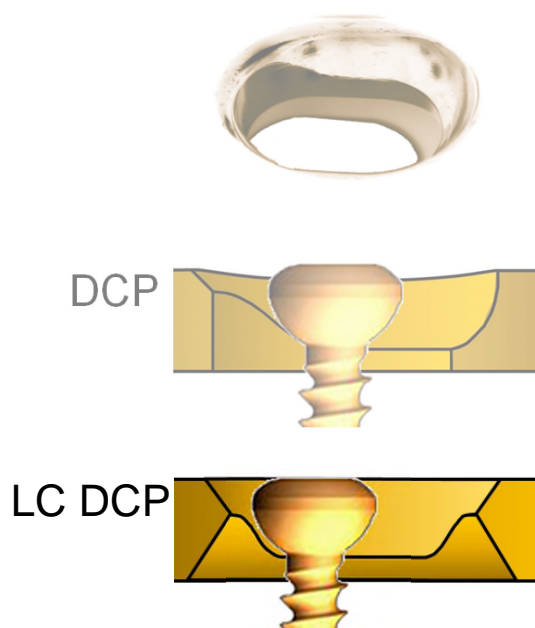


AO

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

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

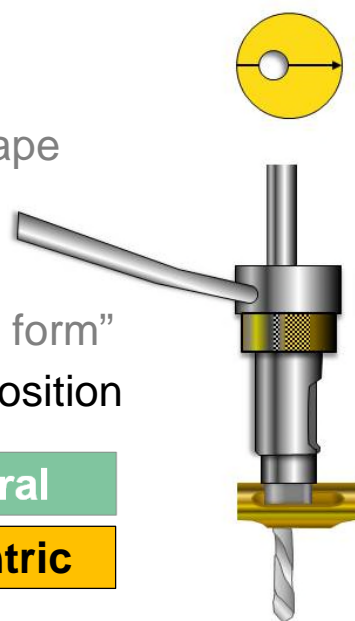
Plates—holes: DCP principle



- Oval shape
- “Sloping form”
- Screw position

Neutral

Eccentric



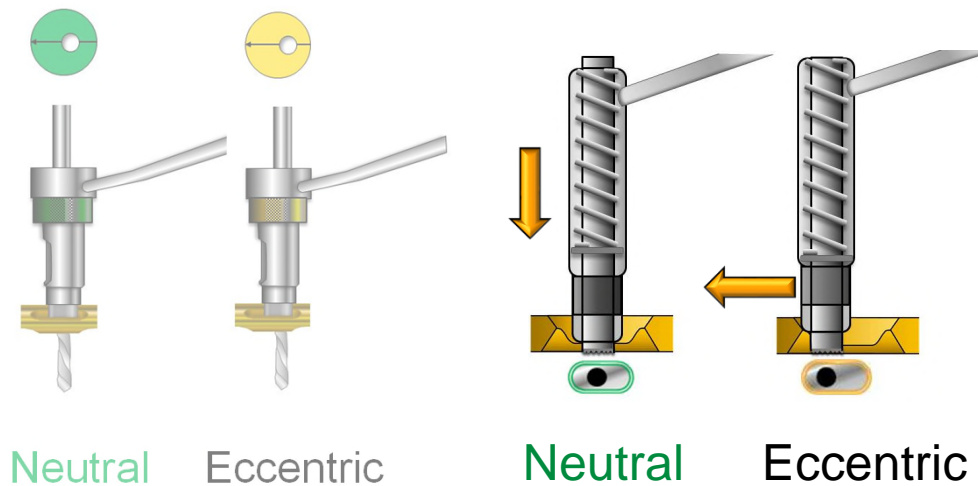
AO

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.

Plates—holes: drill guides

- Universal drill guide

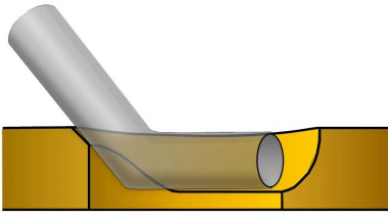


AO

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.

Plates—holes: DCP principle

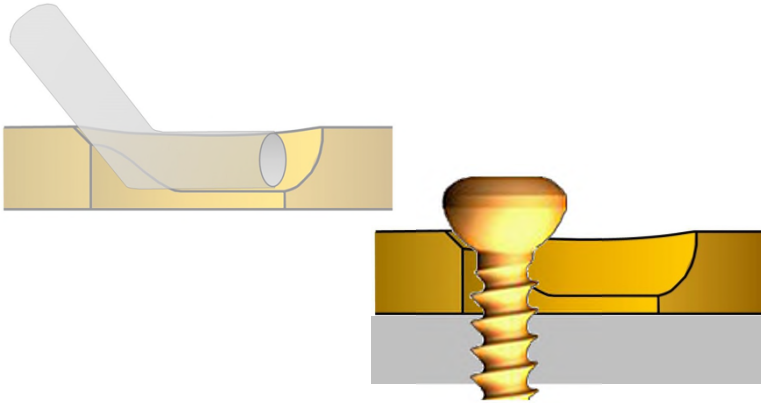


- Sloping shoulder has the form of part of an angled cylinder

AO

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

Plates—holes: DCP principle

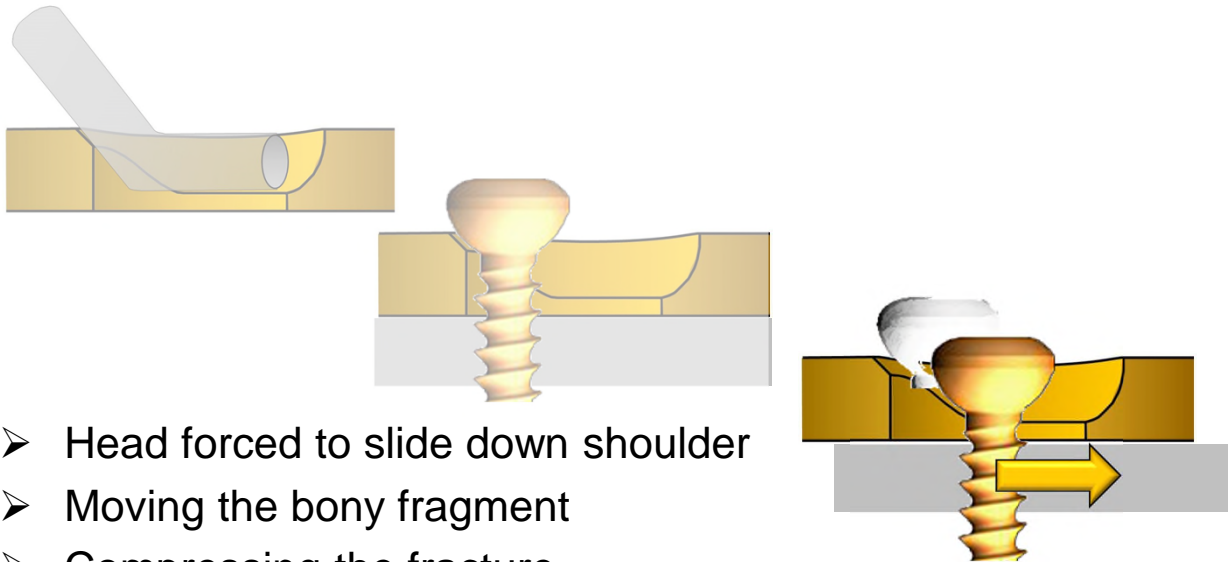


- If screw is inserted eccentrically

AO

If a screw is inserted eccentrically...

Plates—holes: DCP principle



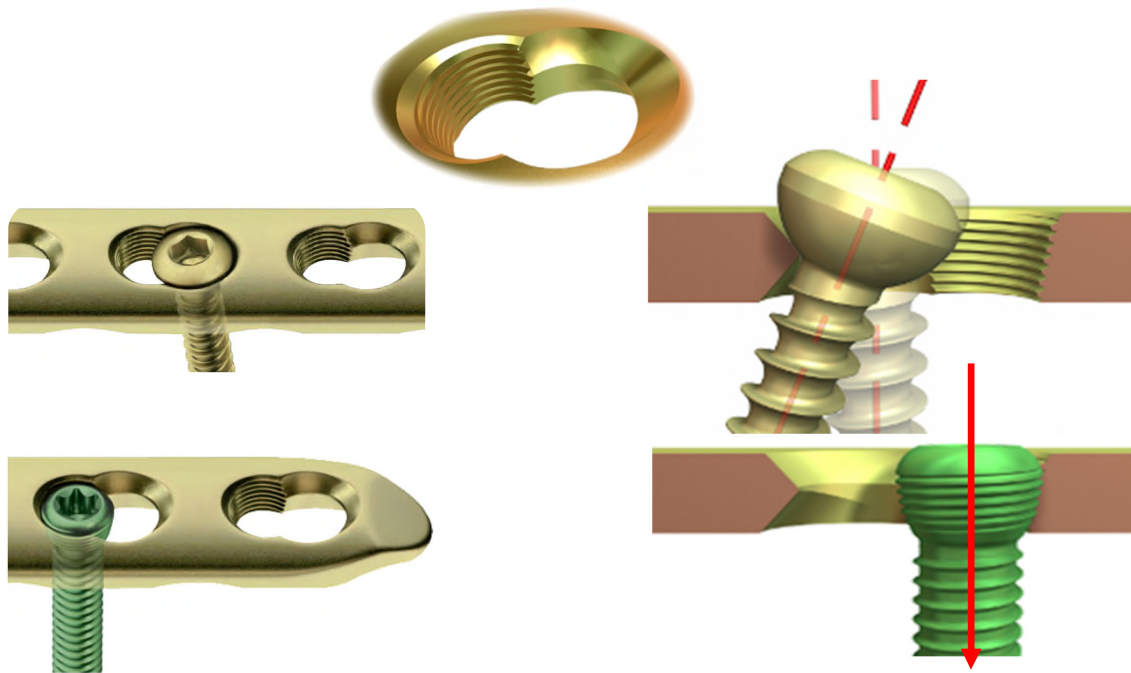
- Head forced to slide down shoulder
- Moving the bony fragment
- Compressing the fracture

AO

... 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.

Such a screw is often referred to as a load screw.

Plates—holes: LCP

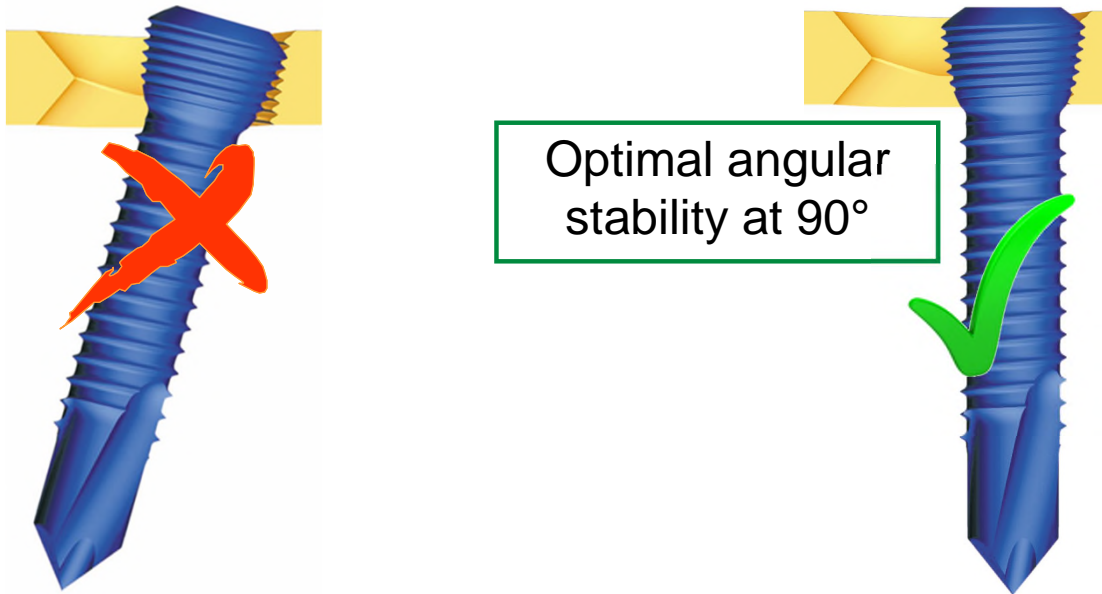


AO

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, but locking head screws must not be angled in the threaded portions of the holes.

Plates—holes: LCP

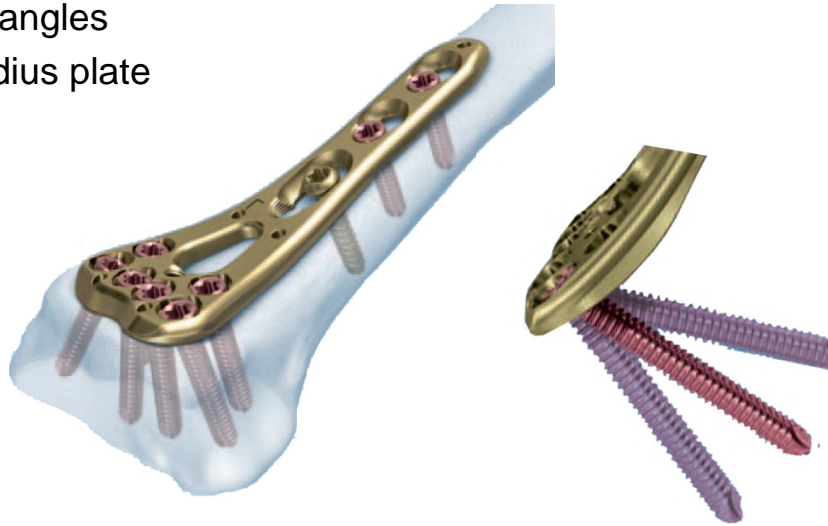


Locking head screws must be inserted carefully: The threads of the screw and the plate must match. Optimal angular stability is gained when the screw is inserted at 90° to the plate, using a special guide. Hence, the importance of the correct use of the LCP drill guide.

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

Plates—holes: LCP

- Threaded holes with range of angulation
 - Variable angles
 - Distal radius plate



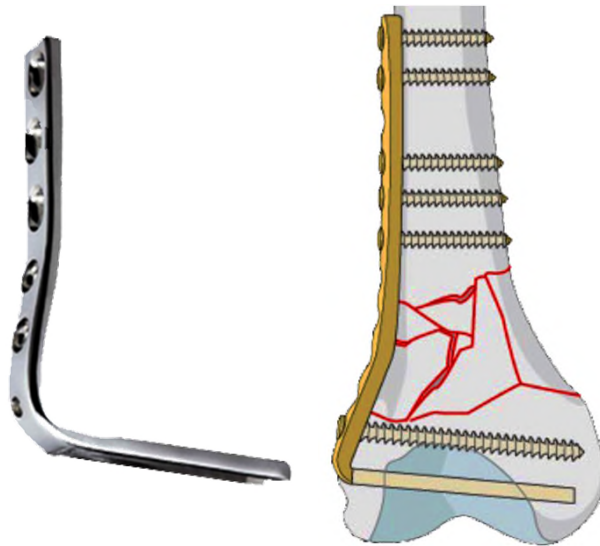
Exceptions

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—angular stability

- Angled blade plate 95°
 - Fixed angle device
 - For metaphyseal fractures

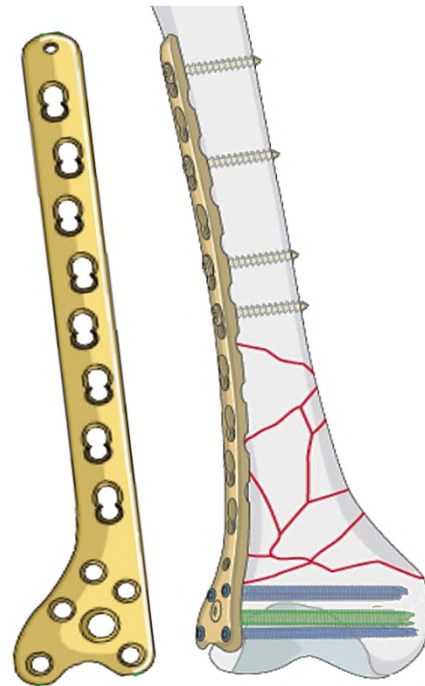
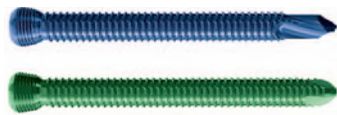


Prior to the introduction of locking plate technology, angular stability, especially for the management of metaphyseal fractures, was achieved by the use of fixed angle devices. The 95° angled blade plate, illustrated here, is one such implant. A high level of surgical experience is required to use these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

These are still the implants of choice for many femoral osteotomies.

Plates—angular stability

- Threaded LCP holes with locking head screws:
 - Achieve angular stability
 - Hold better in osteoporotic bone



Condylar LCP

AO

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

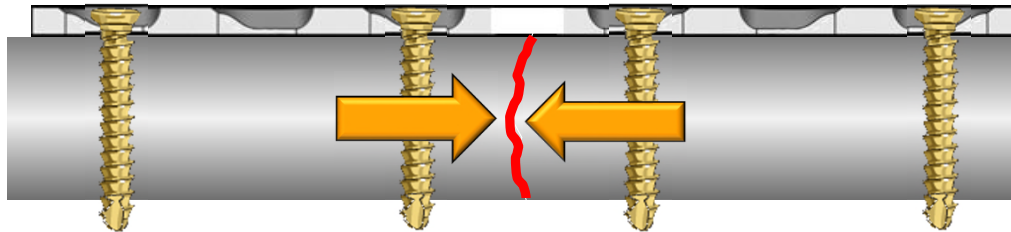
- Compression
- Neutralization/protection
- Buttress
- Bridging/internal fixator
- Tension band

AO

Plates perform several different functions, which will now be considered.

Note: the name of a plate and a plate's function should not be confused. Eg, a DCP can also be applied as a bridging plate.

Plates—functions: compression



Eccentric

Neutral

AO

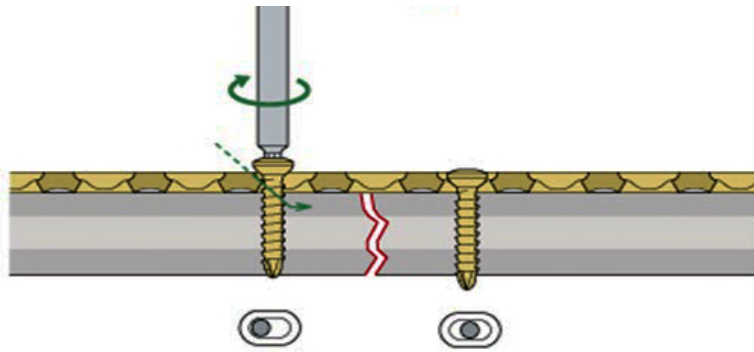
Compressing together the main fragments of a single plane fracture can result in absolute stability, that is, the complete abolition of interfragmentary movement.

Interfragmentary compression in single plane, diaphyseal fractures, can be achieved by exploiting the eccentric loading capabilities of the dynamic compression family of plates.

Remember when we discussed the function of the DCP holes?

Plates—functions: compression

- Neutral screw
- Eccentric screw



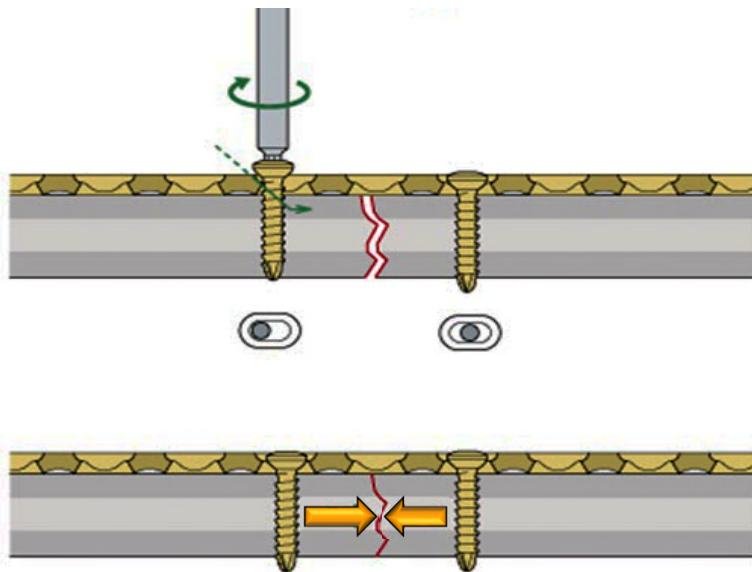
AO

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.

Plates—functions: compression

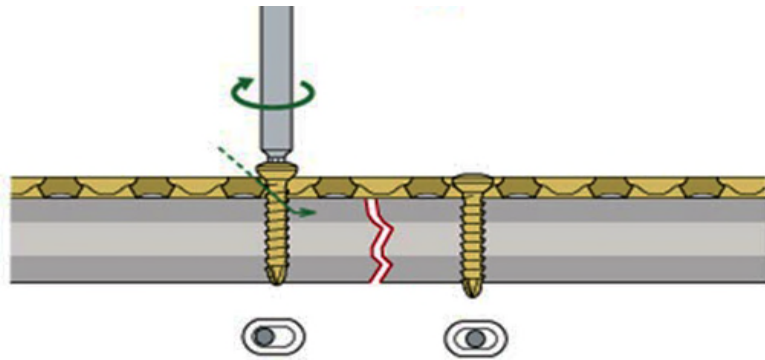
- Neutral screw
- Eccentric screw
- Eccentric screw fully tightened



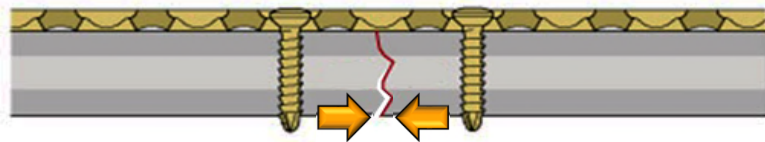
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As the load screw is fully inserted, it engages and slides down the sloping surface of the plate hole, and the screw and bone move toward the fracture, compressing it.

Plates—functions: compression



- Gap in opposite cortex



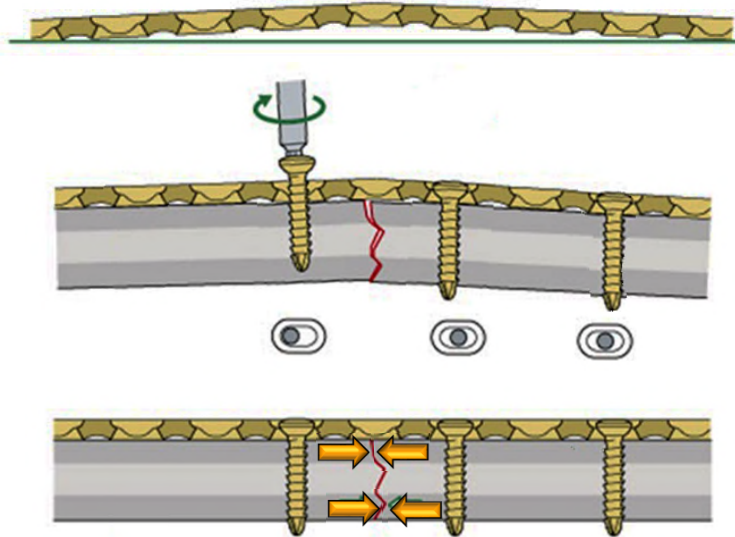
AO

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.

Plates—functions: compression

- “Overbend” the plate



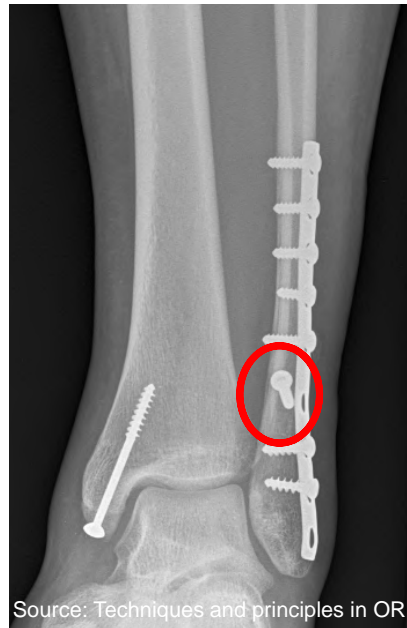
The solution to this problem is to “overbend” the plate so that its center stands off 1–2 mm from the anatomically reduced fracture surface.

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.

Plates—functions: neutralization

- 1/3 tubular plate protects lag screw



AO

A primary lag screw fixation, exerting interfragmentary compression, can be vulnerable to disruption by physiological bending and/or rotational forces.

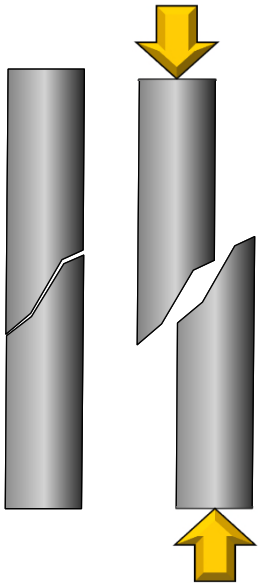
Such a primary fixation is usually protected by the use of a plate, spanning from one main fragment to the other – this “neutralizes” the disruptive forces.

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.

Here is an example of a 1/3 tubular plate protecting the lag screw fixation of the distal fibula in an ankle injury.

Plates—functions: buttressing

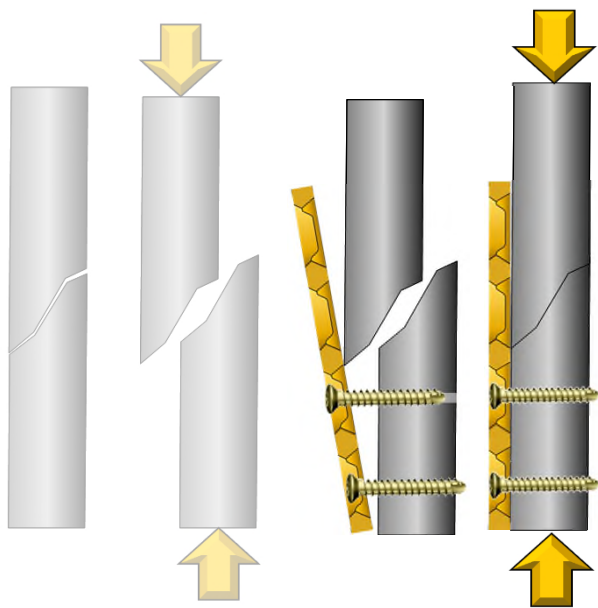


- Fractures tend to shorten

AO

Many fractures tend to shorten and displace under axial load.

Plates—functions: buttressing

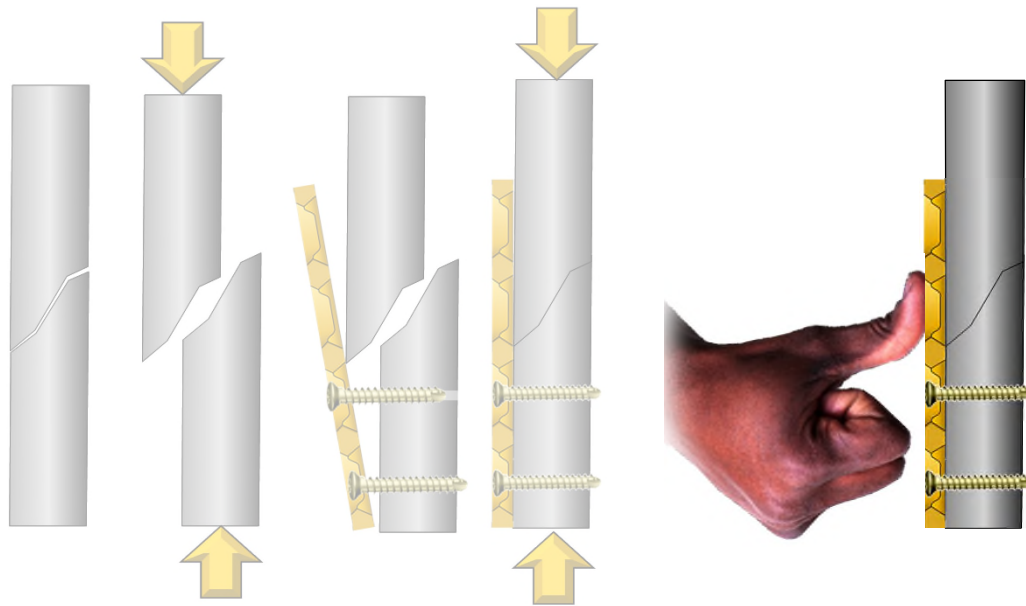


- Fractures tend to shorten
- Plate “buttresses” other fragment

AO

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.

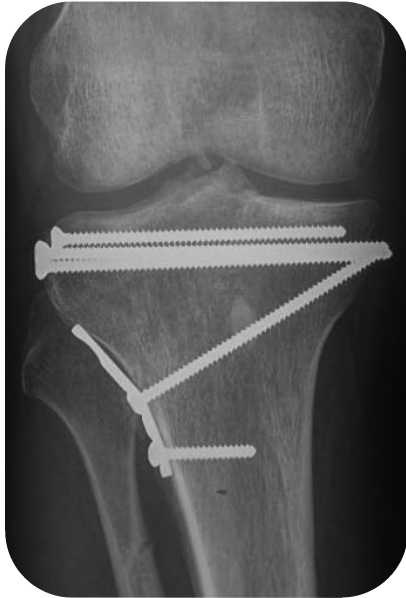
Plates—functions: buttressing



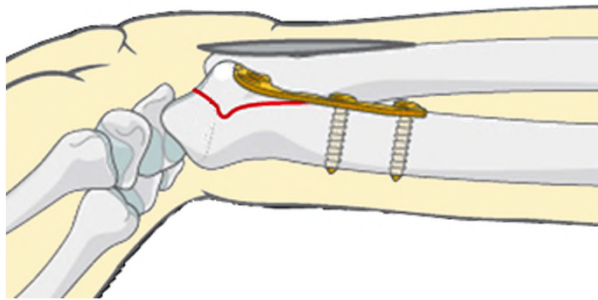
AO

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

Plates—functions: buttressing



- Indications (examples)
 - Tibial head fracture
 - Distal radius fracture

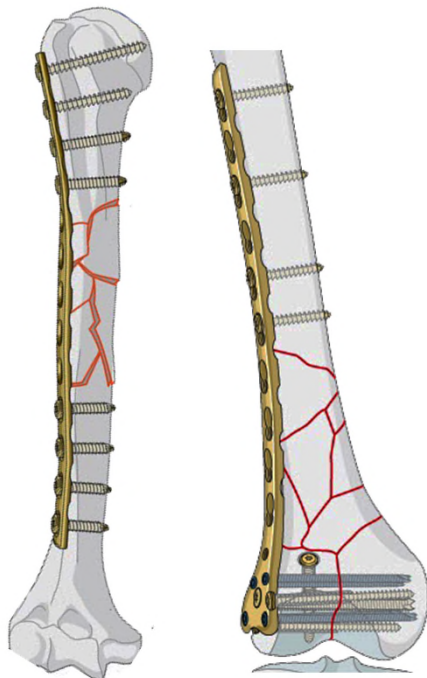


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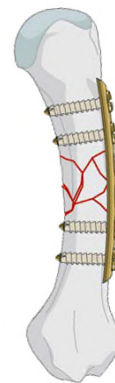
Here are two examples of a buttressing plate holding reduced a tibia head and an anterior marginal distal radial fracture (Barton's fracture).

Courtesy

Plates—functions: bridging



- Diaphyseal fractures
 - Humerus
 - Femur
 - Phalanges



AO

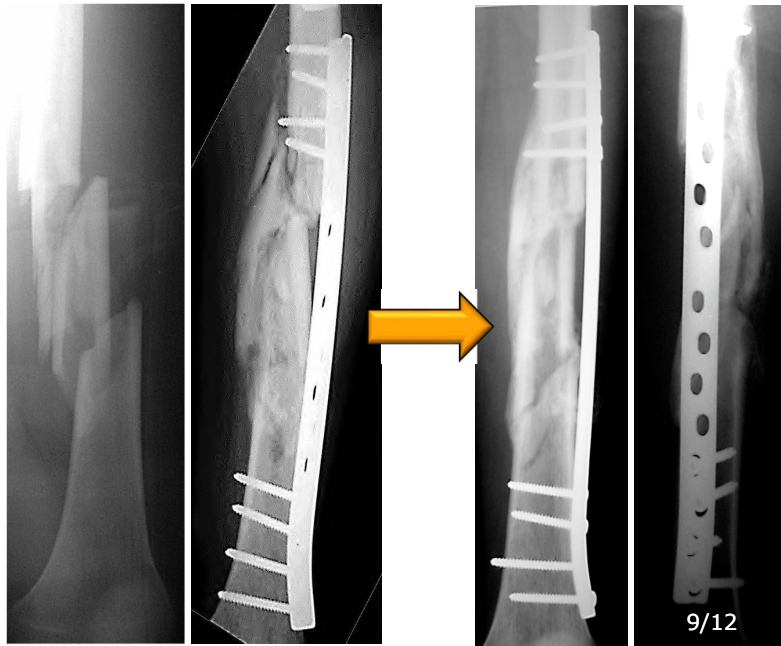
In comminuted diaphyseal fractures, a plate is often applied, spanning the multifragmentary zone, and attached only to the main fragments. This is used to restore length, axial alignment, and rotational alignment.

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

Here are three examples of multifragmentary diaphyseal fractures:

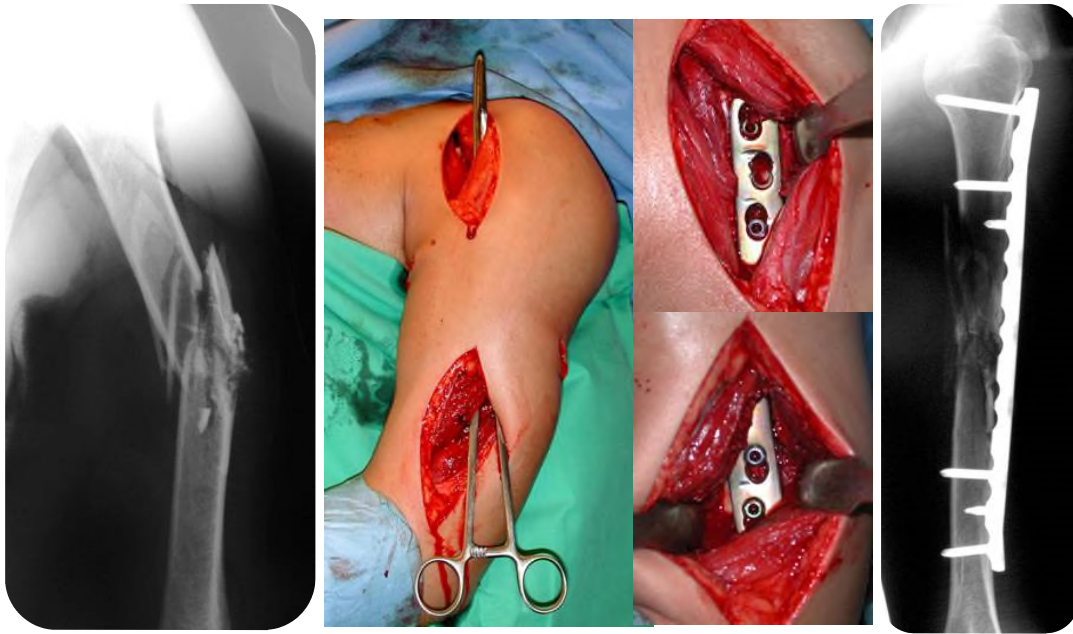
- Humerus
- Femur
- Phalanges

Plates—functions: bridging



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

Plates—functions: bridging



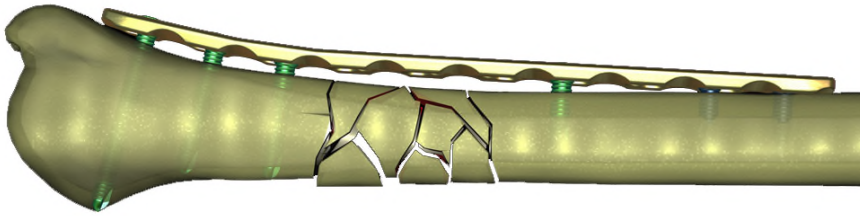
AO

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.

Courtesy

Plates—functions: bridging



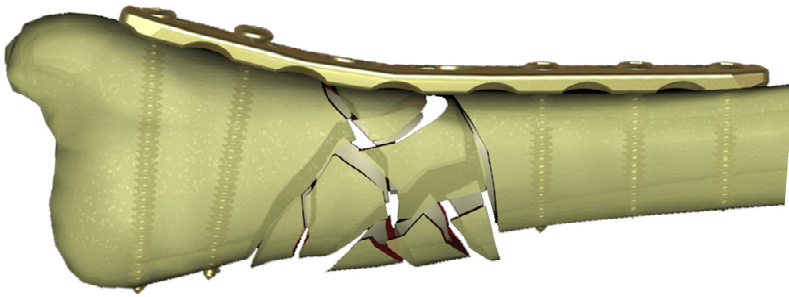
- LCP used with locking head screws
 - as “internal fixator”
 - no precise contouring required

AO

Here 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.

Plates—functions: bridging



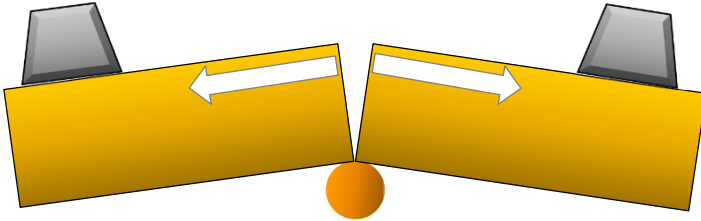
- LCP used with conventional screws
 - as conventional bridge plate
 - exact contouring required

AO

In this example, an LCP is 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.

Plates—functions: tension band

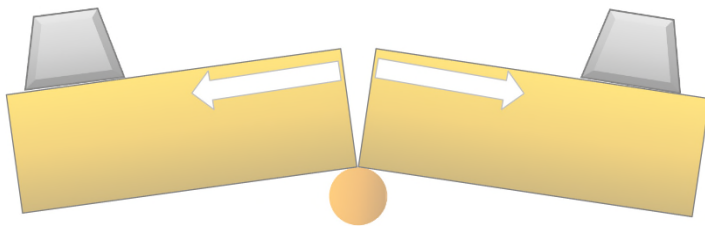


- Tension
- creates fracture

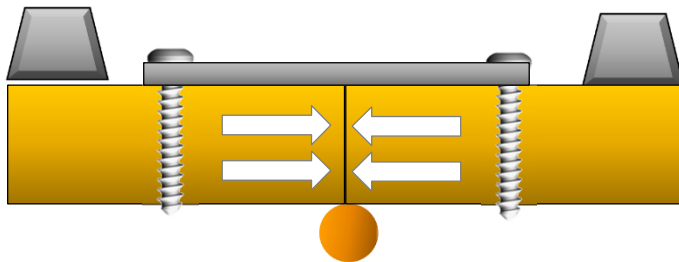
AO

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.

Plates—functions: tension band



- Tension
 - creates fracture

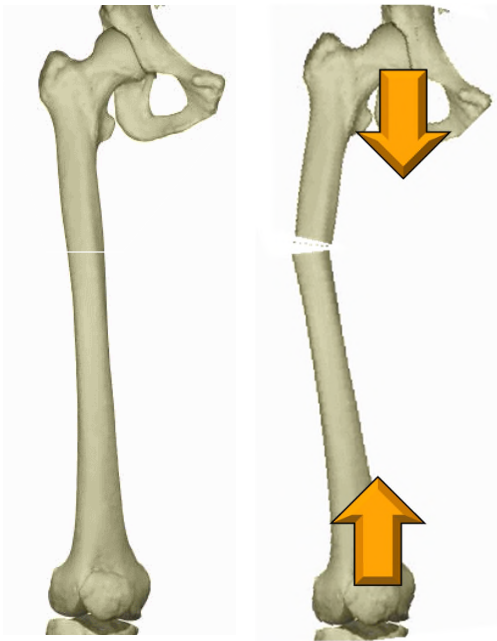


- Plate
 - resists tension
 - generates compression under load

AO

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.

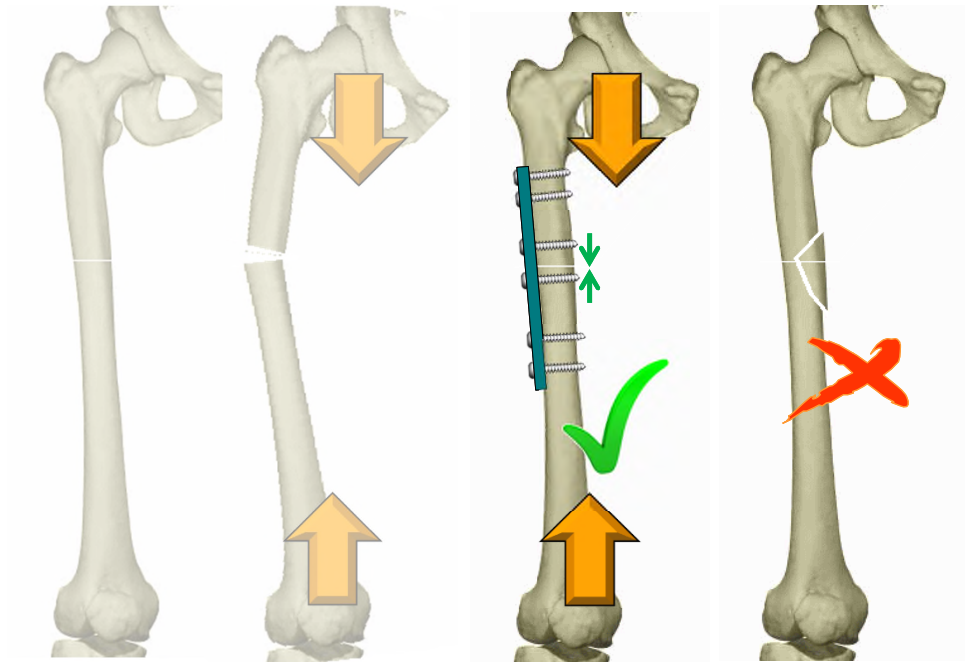
Plates—functions: tension band



AO

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

Plates—functions: tension band

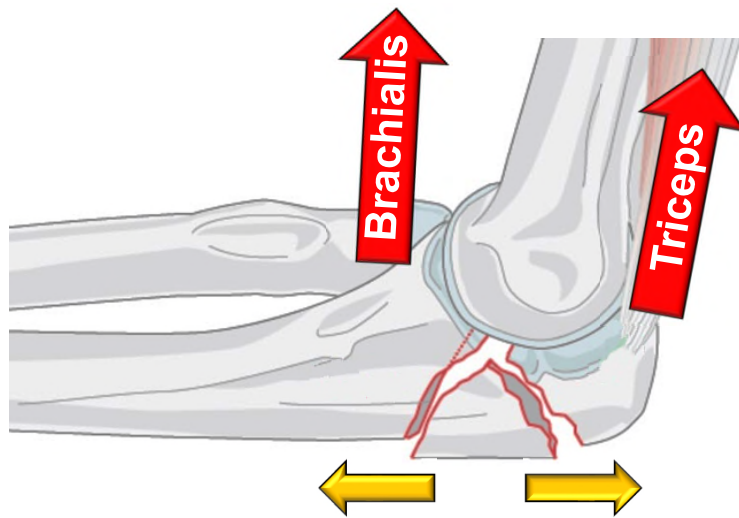


AO

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.

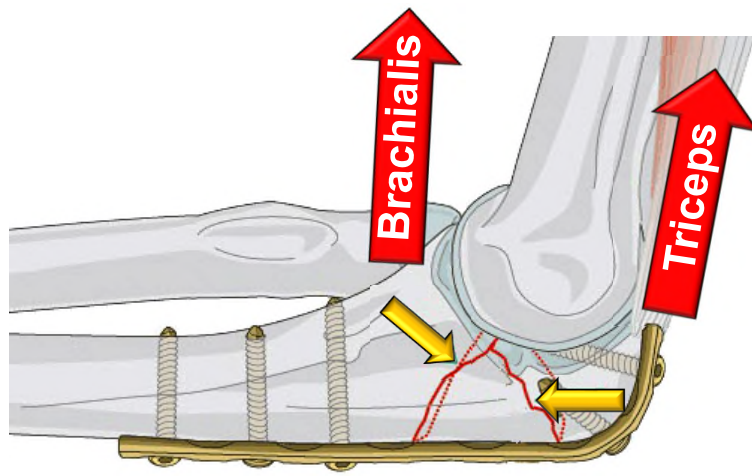
Plates—functions: tension band



AO

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

Plates—functions: tension band



AO

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.

Questions

AO

Optional

Insert questions to check learning

Which drill guide should be used for conventional screws in an LCP ?

1. LCP drill sleeve

2. LCP drill guide

3. Universal drill guide

AO

Optional

Insert questions to check learning

Which drill guide should be used for conventional screws in an LCP ?

1. LCP drill sleeve

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3. Universal drill guide



AO

Optional

Insert questions to check learning

The locking compression plate can be applied as a:

1. Buttress plate

2. Internal fixator

3. Compression plate

AO

Optional

Insert questions to check learning

The locking compression plate can be applied as a:

1. Buttress plate



2. Internal fixator



3. Compression plate



AO

Optional

Insert questions to check learning

A reconstruction plate

1. Can be contoured in multiple planes
2. Should only be contoured in one plane
3. Is an anatomically precontoured plate

AO

Optional

Insert questions to check learning

A reconstruction plate

1. Can be contoured in multiple planes ✓

2. Should only be contoured in one plane

3. Is an anatomically precontoured plate

AO

Optional

Insert questions to check learning

Summary

You should now be able to:

- Outline the evolution of plates
- Describe the function of compression holes
- List different functions of plates

AO

You should now be able to:

- Outline the plate evolution
- Describe the function of compression holes
- List different functions of plates