

Plates – form and function

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How to use this handout?

The left column is the information as given during the lecture. The column at the right gives you space to make personal notes.

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

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 were 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.

The LC DCP has a fluted undersurface.

Footprint of a DCP



Footprint of an LC DCP



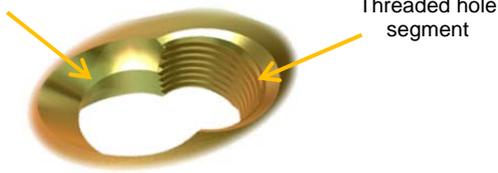
Locking compression plates



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.

Standard hole segment



Threaded hole segment



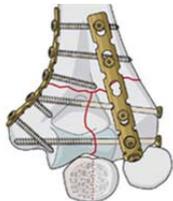
This means that the LCP can be used for conventional plating functions, and also with locking head screws to produce angular stability.



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, ...

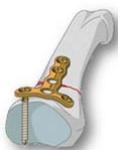


...and are useful in complex anatomical sites, such as the distal humerus, the pelvis, the clavicle, etc.



Anatomical plates

Here are some examples of other anatomically preformed plates:



T-plate for phalanges



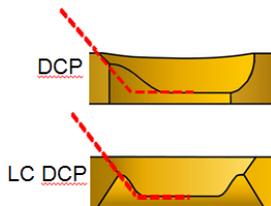
L and LCP contoured plates for distal radius



Ulna plates and distal humerus plates

Plates – holes

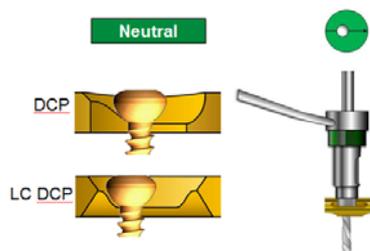
Dynamic compression plates are designed with screw holes of a particular form. The holes are oblong and the portion of each hole distant from the fracture has a sloping form or "shoulder".



Note that the DCP and LC DCP have different forms.

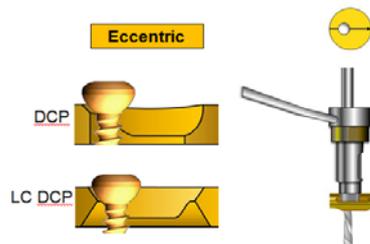
Screw insertion – neutral position

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

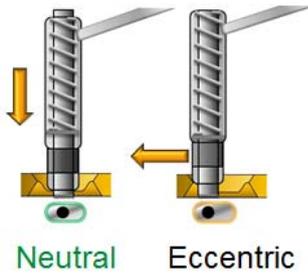
A screw can be inserted in any DCP hole in an eccentric position in order to get compression at the fracture site when tightening. Special load drill guides – colored yellow – are used to position the drill bit eccentrically.



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

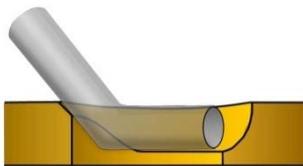
Spring-loaded universal drill guide

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.

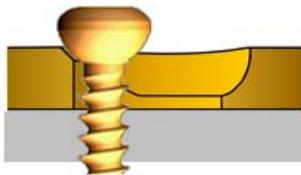


If there is no downward pressure on the barrel but it is drawn to the edge of the plate hole away from the fracture, an eccentric load hole can be drilled.

DCP principle



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



If a screw is inserted eccentrically...

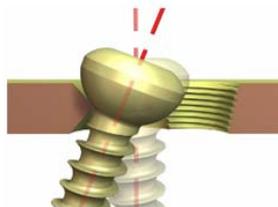


... so that its head, on final tightening, slides down the sloping profile of the hole, the screw/bone unit will be shifted toward the fracture and the fracture plane will thereby be compressed.

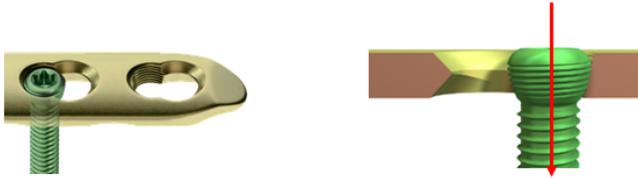
Such a screw is often referred to as a load screw.

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.

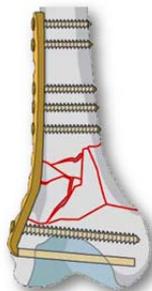


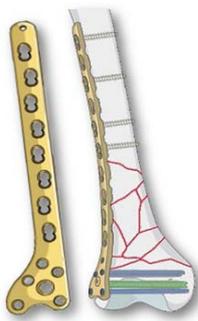
Plates providing angular stability



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.

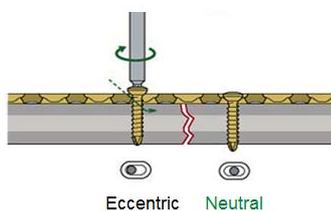
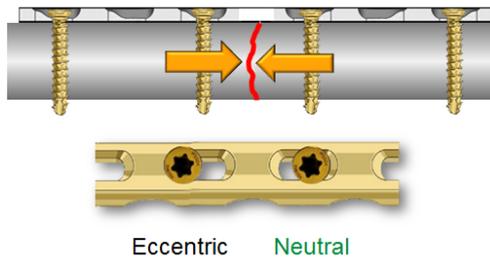
Because the screws in the metaphyseal fragment purchase in the bone, and also lock into the plate holes, the mechanical equivalent of a fixed angle device can be constructed.

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

Plates – functions

Compression

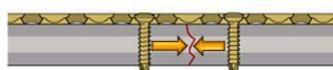
Compressing together the main fragments of a single plane fracture can result in absolute stability, that is, the complete abolition of interfragmentary movement. Interfragmentary compression in single plane, diaphyseal fractures, can be achieved by exploiting the eccentric loading capabilities of the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



in an eccentric (load) mode.

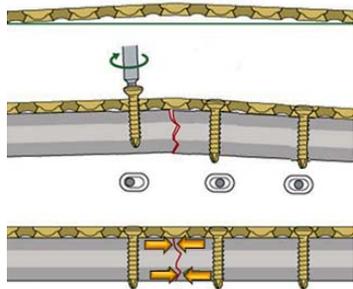
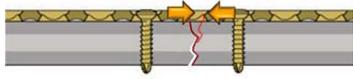
In this diagram, the plate is fixed to the right-hand fragment with a screw inserted in a neutral mode.

A screw is then inserted into the left-hand fragment



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.

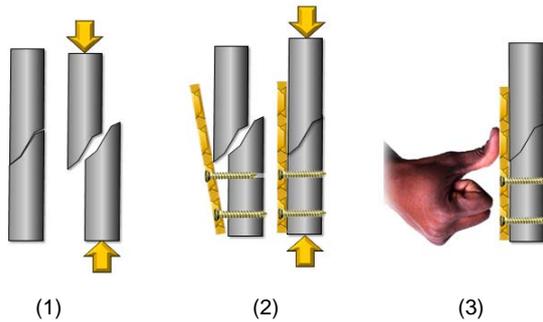


All such forces are then transmitted via the plate, and by-pass the primary lag screw fixation.

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

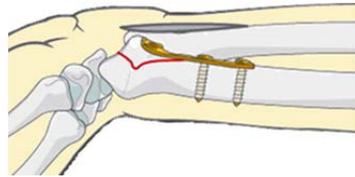
(2) Such a fracture can be stabilized by applying a plate to one main fragment in such a manner that it buttresses the other fragment, so as to prevent displacement.

(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).



Picture R Pesantez



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.

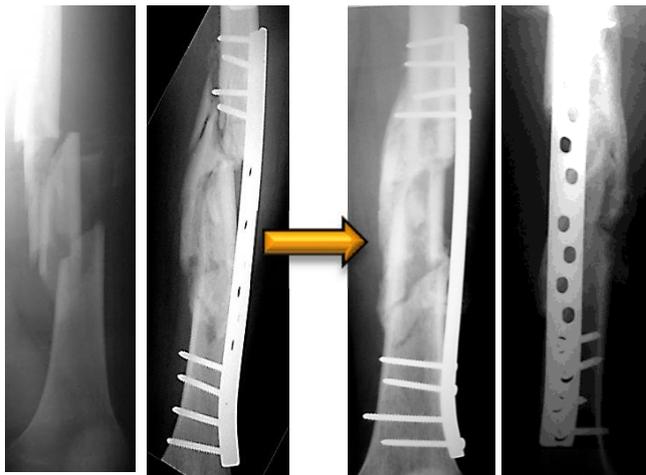
Some examples

Here are three examples:

- Humerus
- Distal femur
- Phalanges



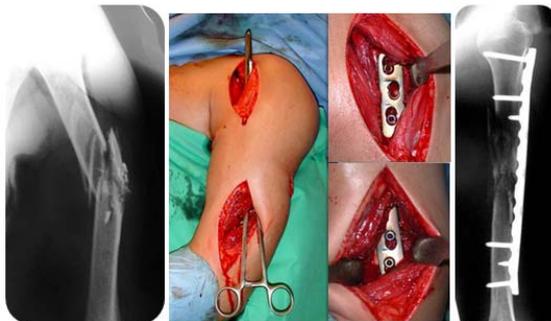
This comminuted femoral shaft fracture was bridged with a plate. After 9 months, healing by callus formation is evident on x-ray.



Treatment with bridging plate

Callus formation (9/12)

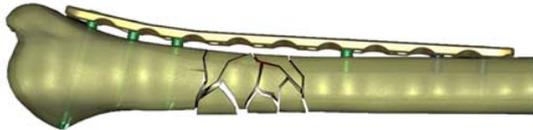
Bridge plating can be performed by either an open technique, or minimally invasively. In this example, with minimally invasive surgery (MIS), the plate was applied to bridge this gunshot injury.



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.

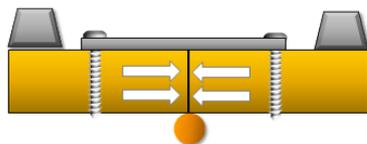


Tension band

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.

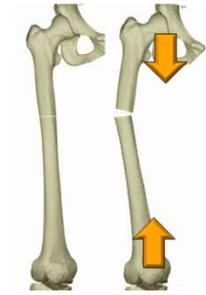


However, if an inelastic band, such as a plate, is anchored to the tension side of the body, the same load will generate compression across the fracture interface.

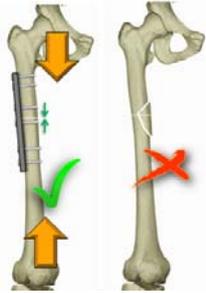


This is known as the tension band principle.

Some examples



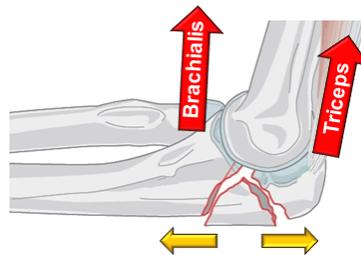
The femur is an eccentrically loaded bone. When axially loaded, the lateral cortex is under tension and the medial cortex bears compressive forces.



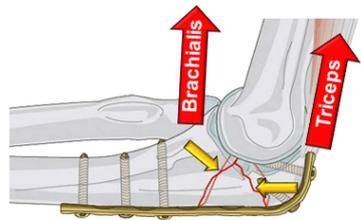
A plate fixed to the lateral cortex will function as a tension band and the eccentric physiological load will cause compressive forces in the medial cortex.

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.



Summary

You should now be able to:

- outline the evolution of plates
- describe the function of compression holes
- list different functions of plates

Questions

1. Which type of drill guide should be used for conventional screws in an LCP?
2. The LCP is used as which type of plate?
3. The reconstruction plates are contoured in which plane(s)?

Reflect on your own experiences

- Which plates do you use? Do you know the application for each of them? Do you know with which type of screws these plates can be used?

- What would you take out this lecture and transfer into your practice?

Notes