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

https://www.youtube.com/watch?v=m6Q_GbKPk44&list=PLuBRb5B7fa_eyBVgz4xb_AqlGcXLIEyRA&index=2

AO TRAUMA

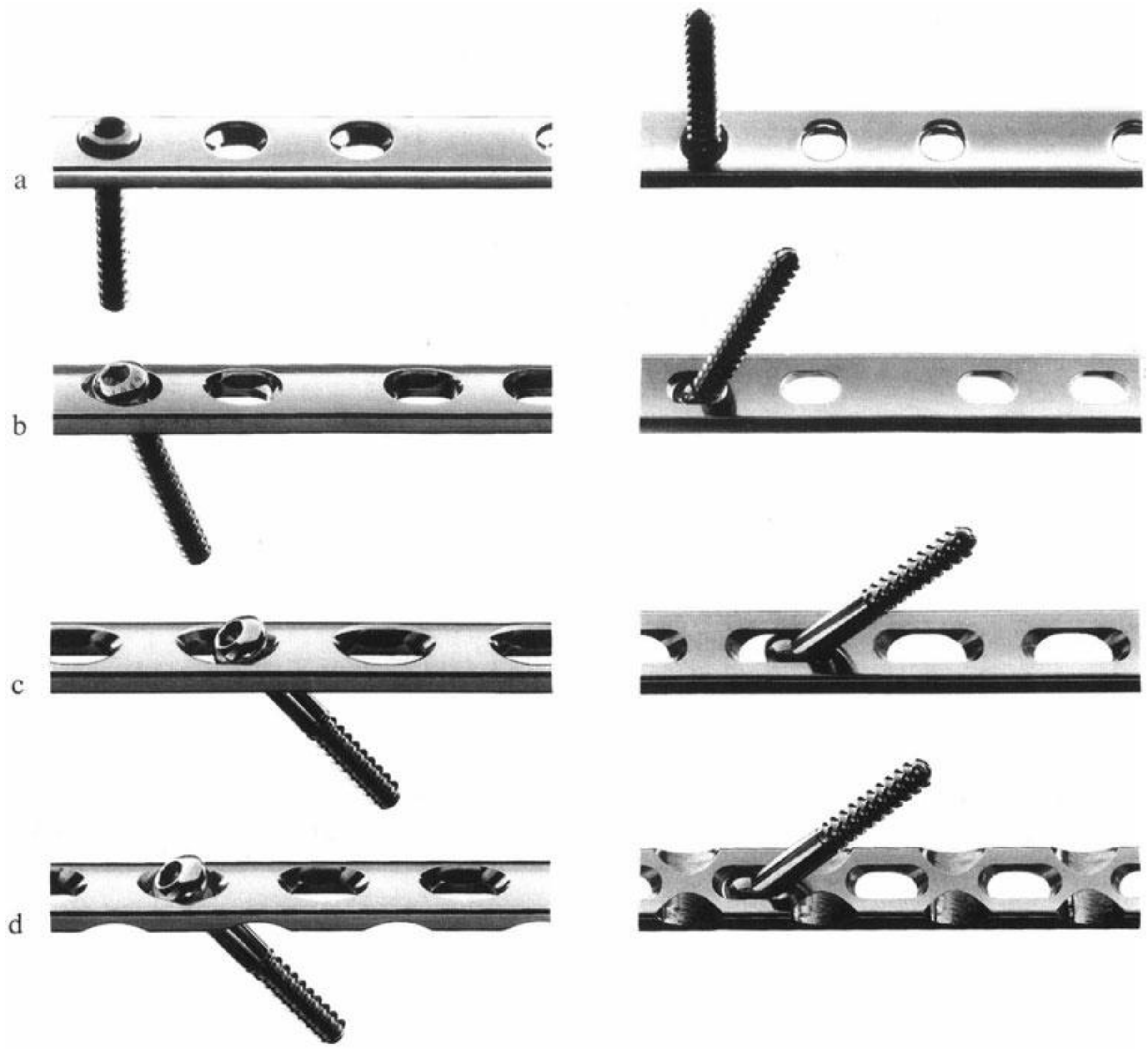
The use of plates in fracture fixation

Abdullah Alkhawaldah

Learning objectives

- Comprehend the different design functions of plates in fracture fixation
- Demonstrate plate features that enable these functions
- Discuss how to use plates for absolute and relative stability
- State the indications for locking plates

Plate designs



The round hole plate (Muller et al. 1963

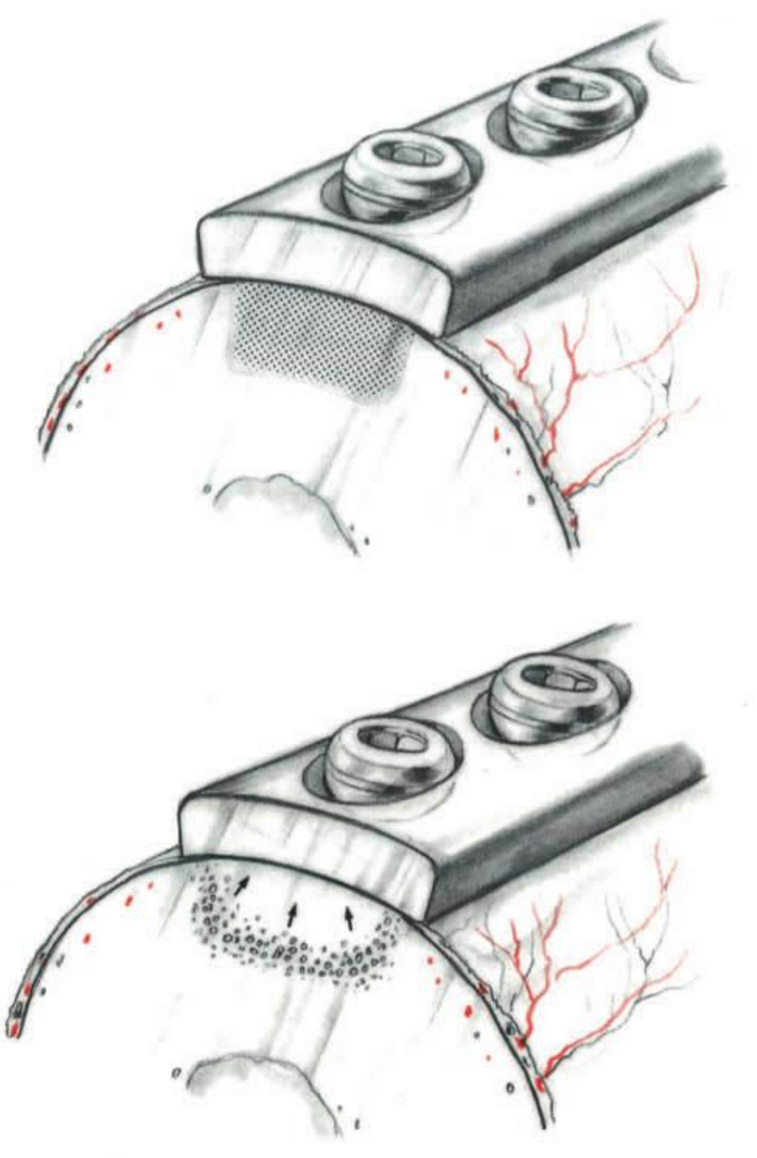
b The dynamic compression plate DCP (Perren et al. 1969

c The dynamic compression unit DCU (Klaue and Perren 1982

d The limited-contact dynamic compression plate LC-DCP (Perren et al. 1989)

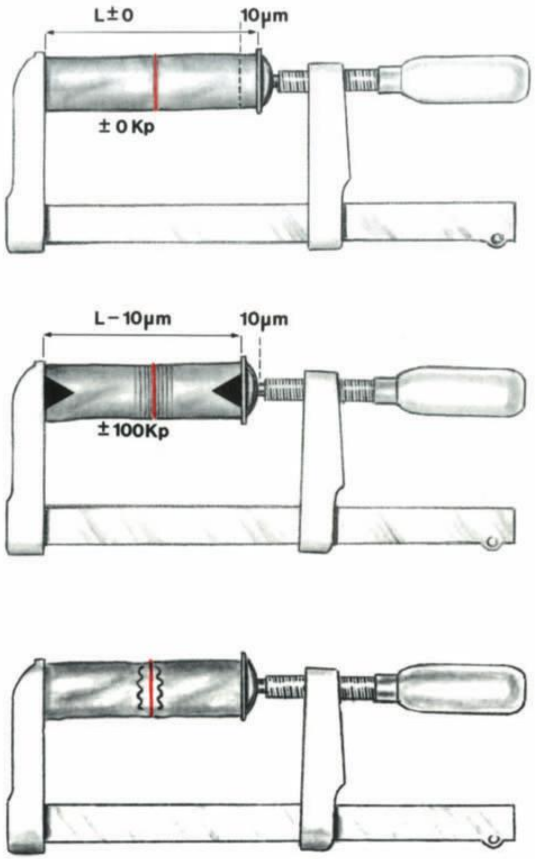

76 mm


5



a

b



a

b

c

The area of plate-bone contact (the plate footprint) is greatly reduced in the LC-DCP. There is less impairment of the capillary network of the periosteum, resulting in a relative improvement of cortical perfusion

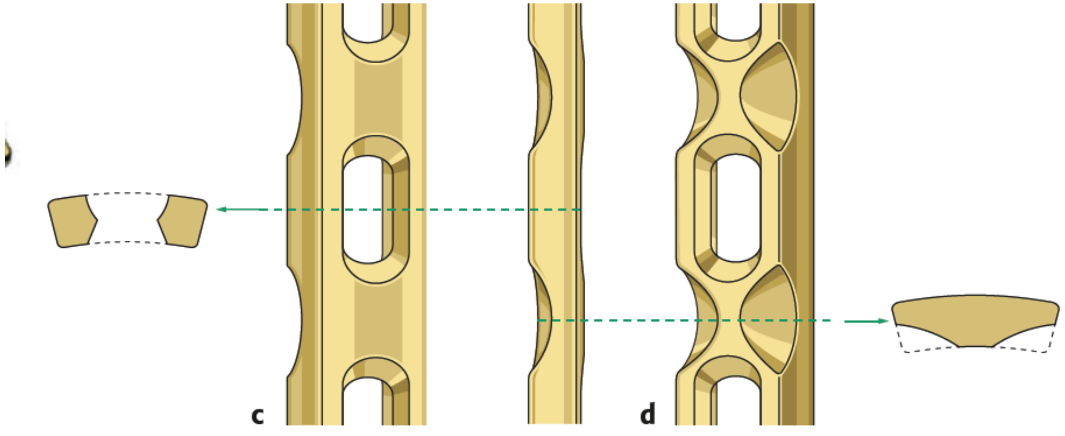
The limited-contact dynamic compression plate LC-DCP

the structured geometry of the undersurface of the

plate results in an even distribution of stiffness, making

contouring easier, and minimizing the likelihood of bends

in the plate being concentrated



The oval shape of the holes allows 25° inclination of the screws in the longitudinal plane and up to 7° inclination

in the transverse plane (

even distribution of stiffness, making

contouring easier, and minimizing the likelihood of bends

in the plate being concentrated

gentle elastic deformation of the entire plate without stress

concentration at one screw hole

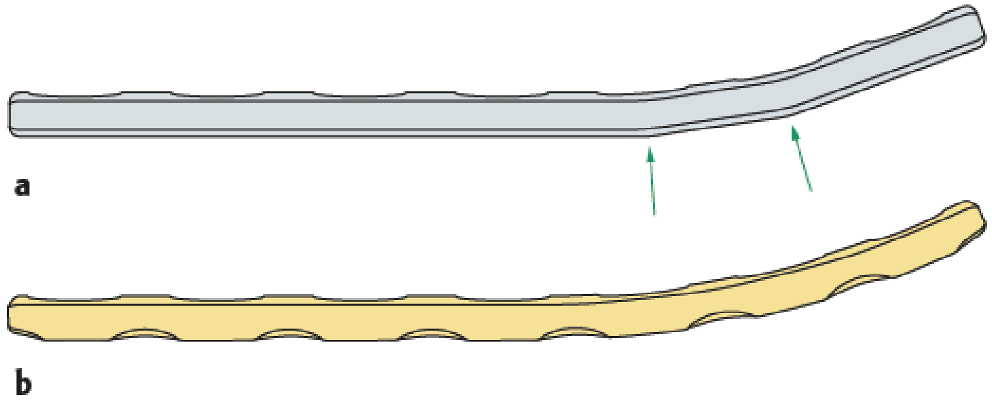
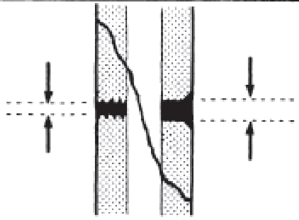
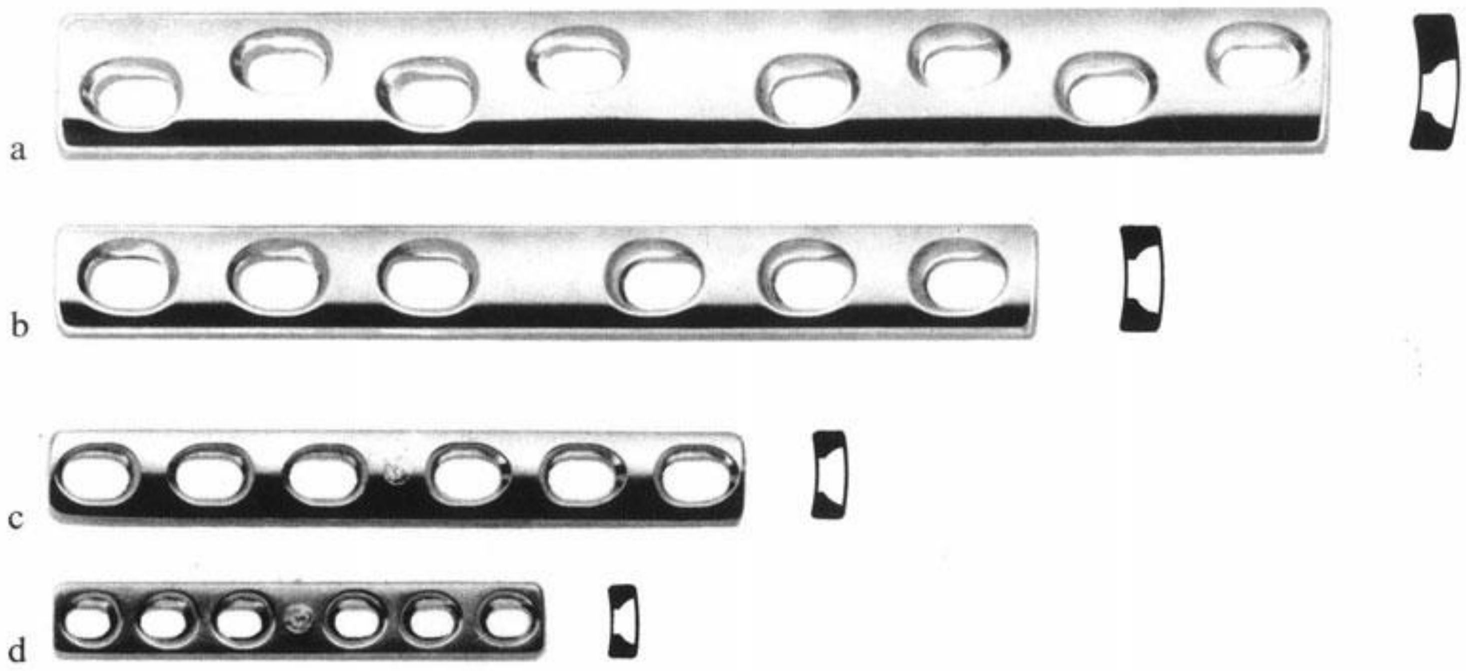


Fig. 3.4

TAP  ∅	PILOT OR THREAD HOLE  ∅		GLIDING HOLE  ∅
1.5	1.1	1.5	1.5
2.0	1.5	2.0	2.0
2.7	2.0	2.7	2.7
3.5/1.25mm	2.5	3.5	3.5
3.5/1.75mm	2.5	4.0	—
4.5	3.2	4.5	4.5
(4.5)	3.2	4.5	—
6.5	3.2	6.5	(4.5)



a The broad DCP (plate and its profile) to be used on the humerus and femur.

b The narrow DCP (plate and its profile) to be used on the bones of the forearm, on the tibia and

on the pelvis.

c The 3.5-mm DCP (plate and its profile) to be used with 3.5-mm cortex screws. It should be used on

the radius and ulna.

d The 2.7-mm DCP (plate and its profile) to be used with 2.7-mm cortex screws.

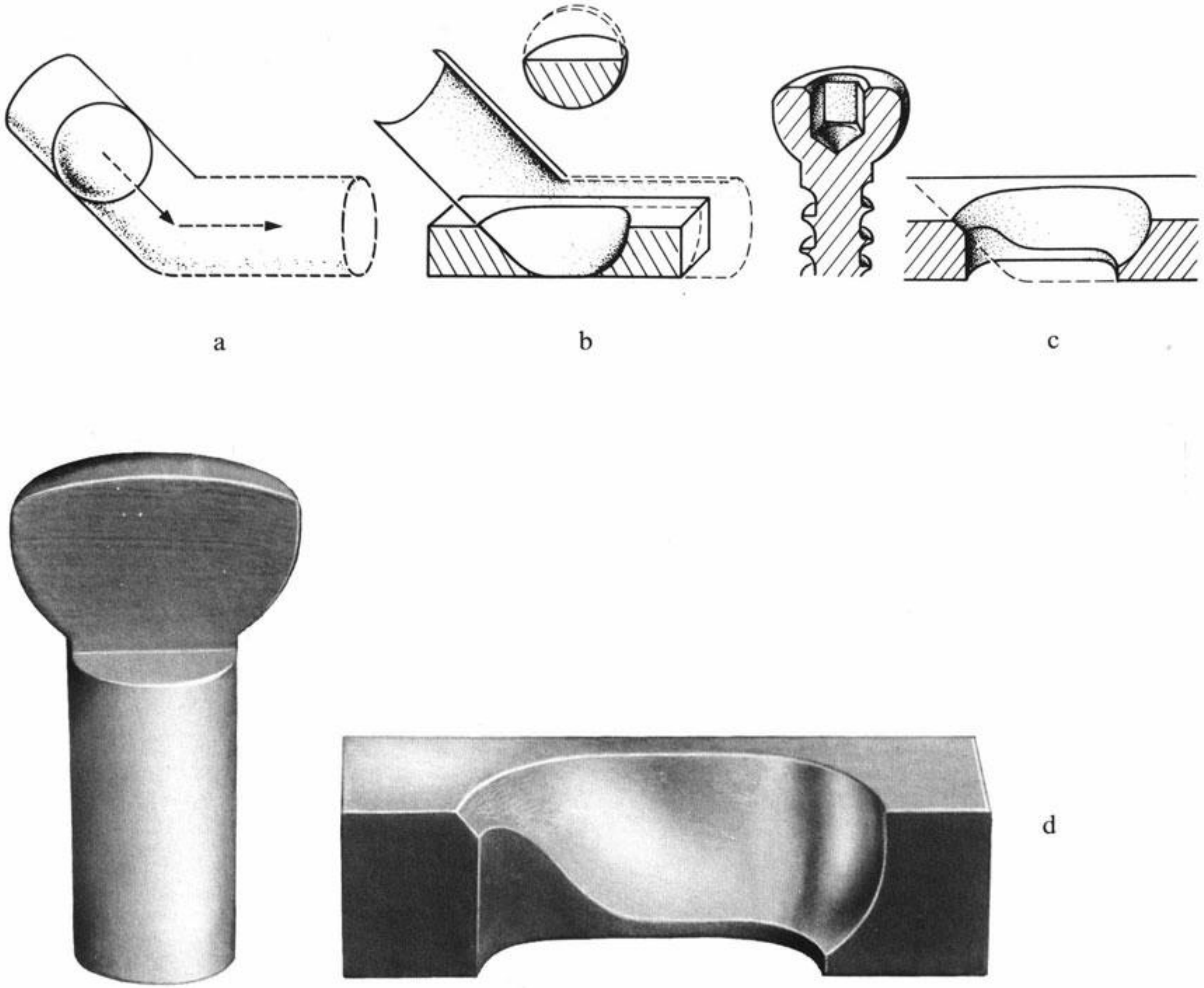
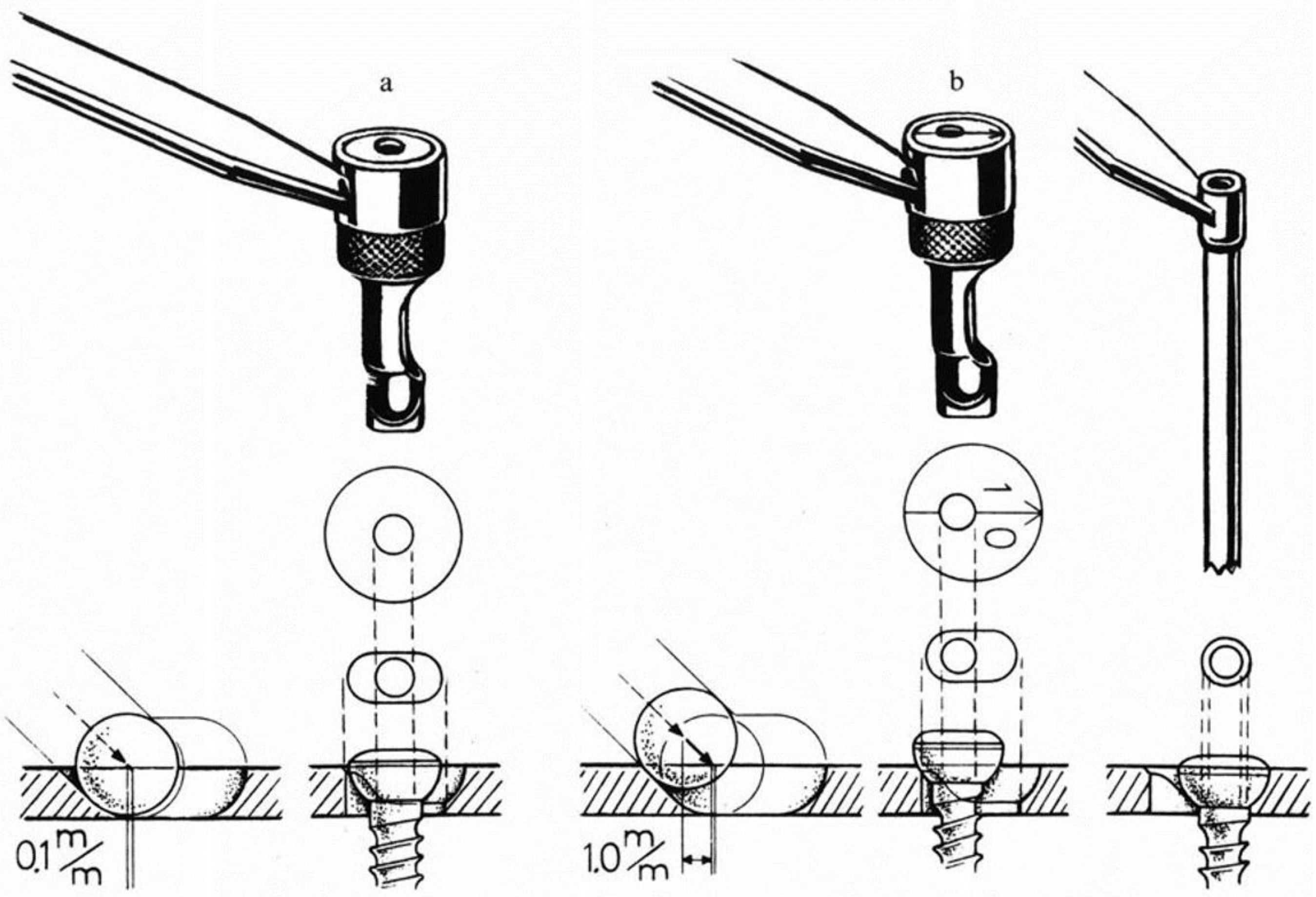
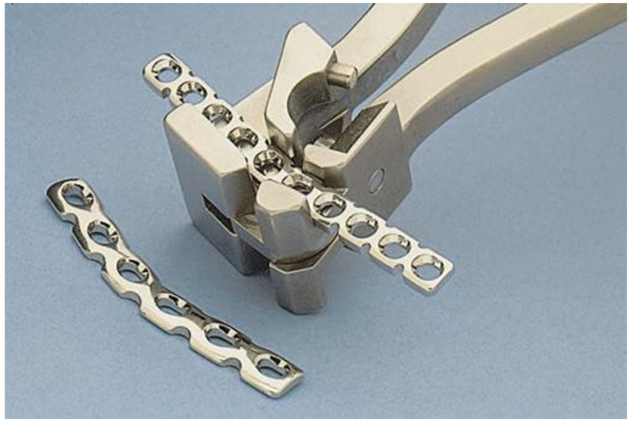

a
b
c
d

Fig. 3.37

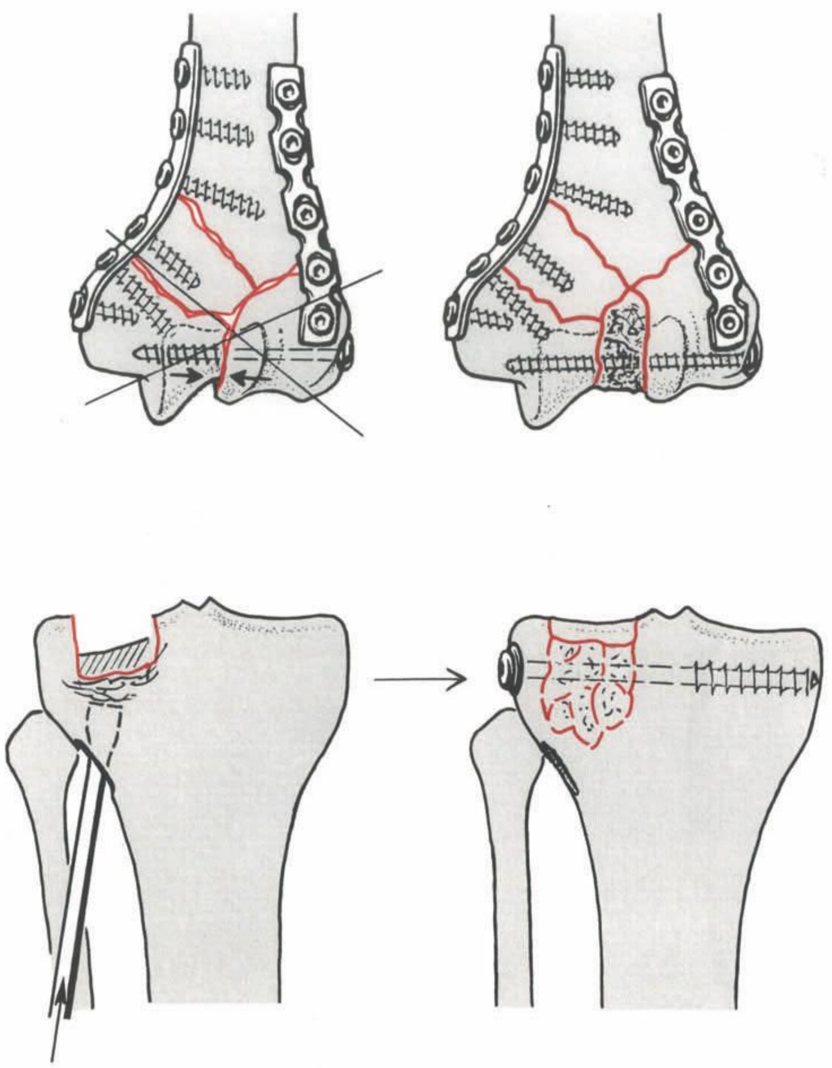


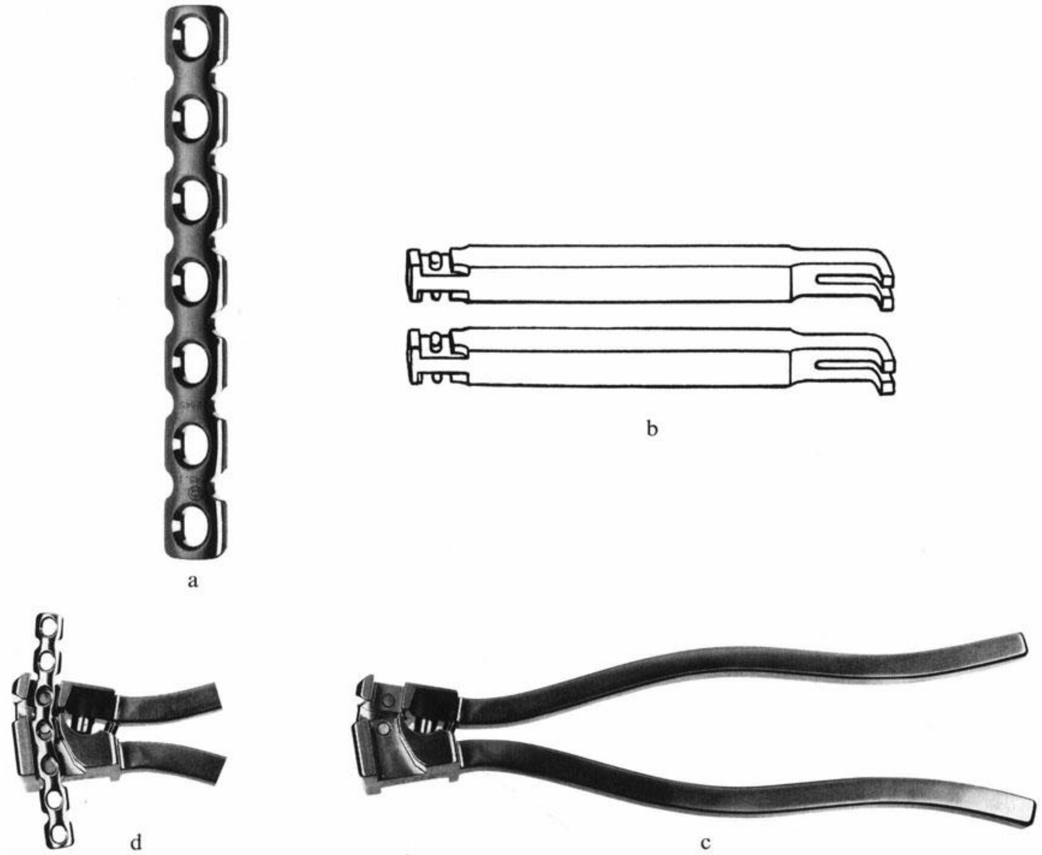
Reconstruction plates

complex 3-D geometry, such
as the pelvis, acetabulum, distal humerus, distal tibia, and
clavicle.



deep notches on the edge of the plate. These notches are situated between the holes and allow accurate contouring of the plate in all planes

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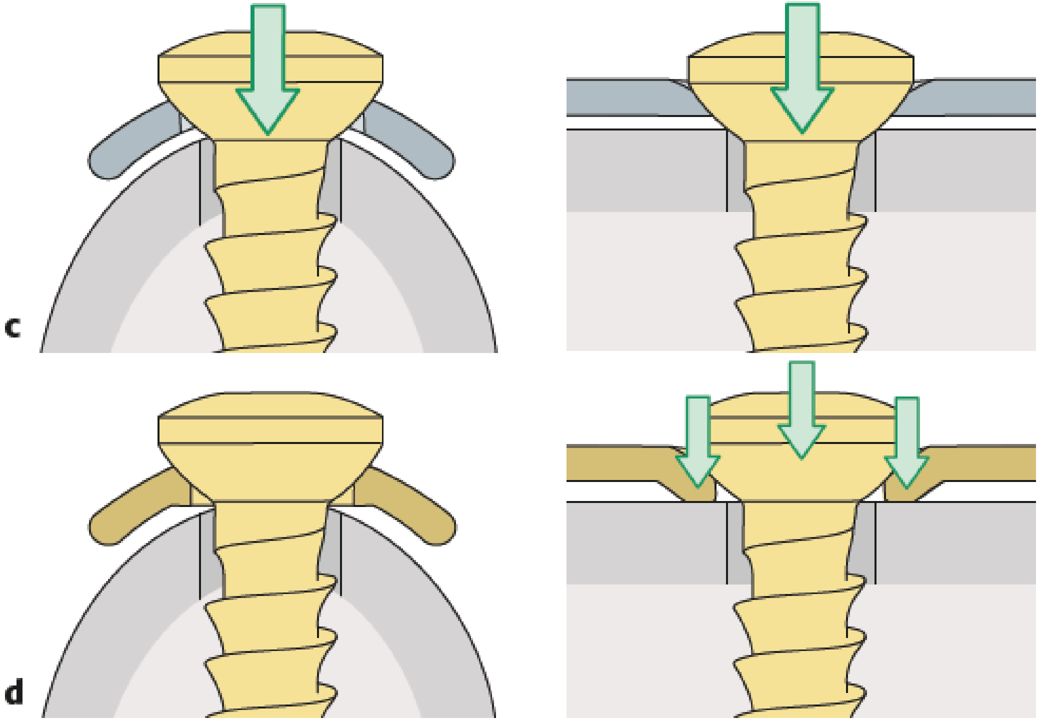
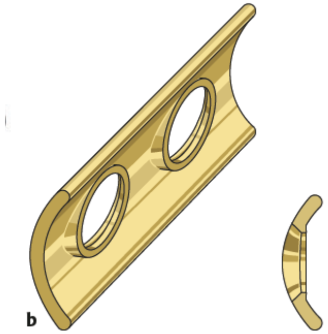
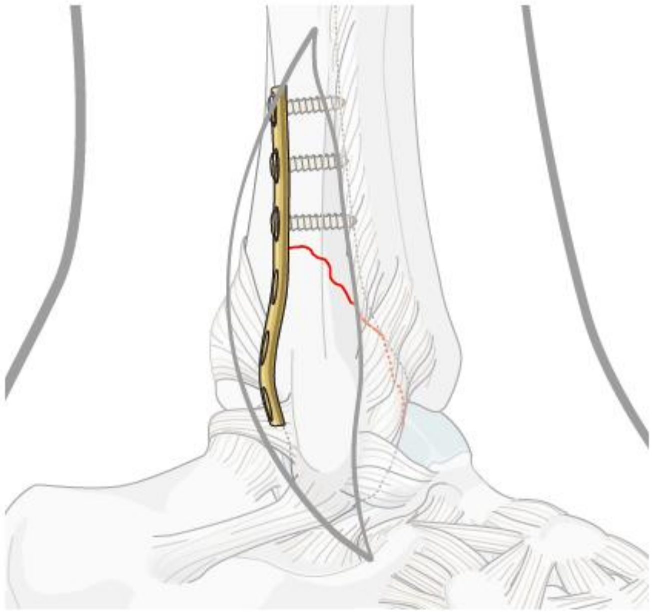
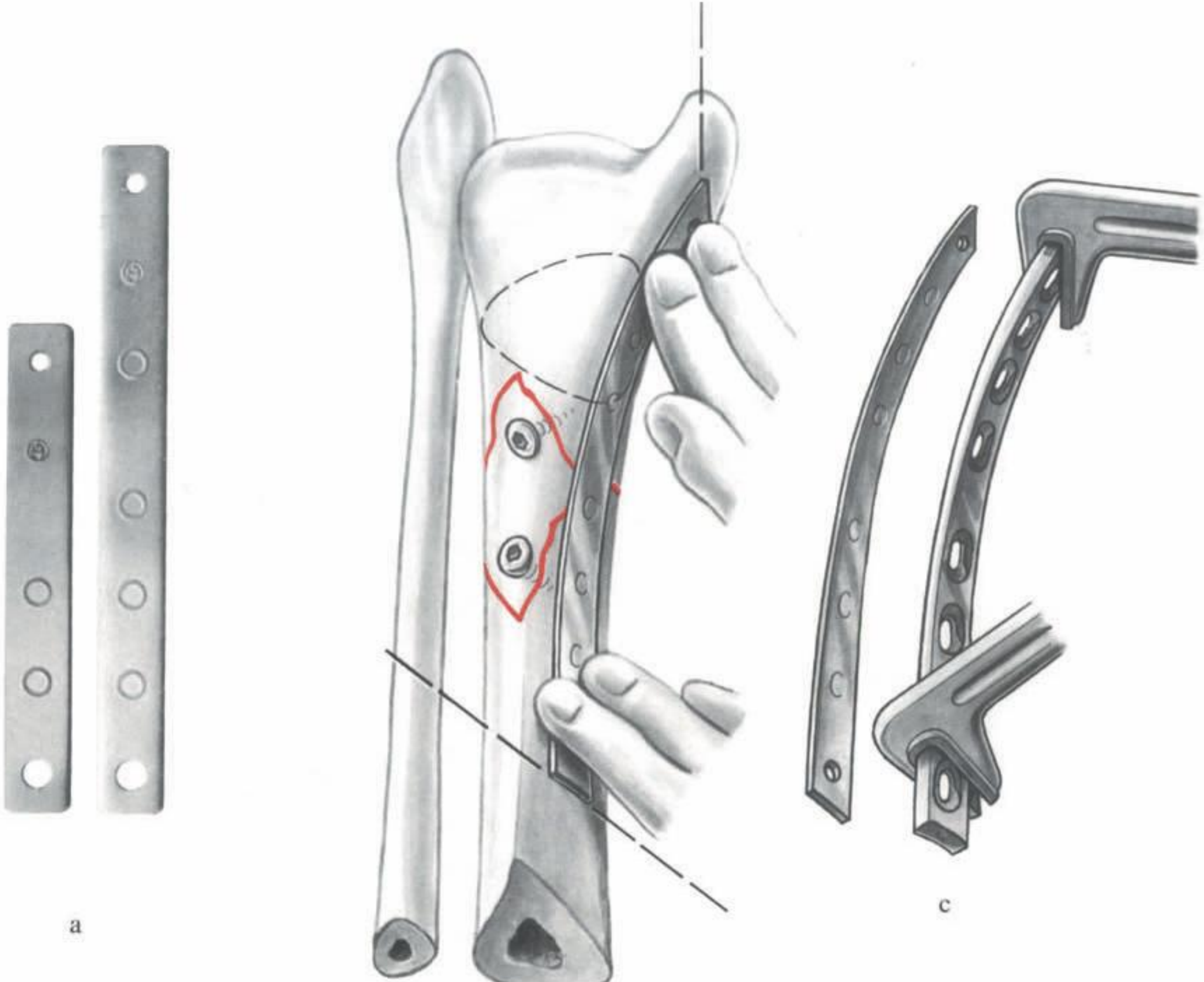






The collar around the hole of the one-third tubular plate prevents the screw head from protruding

and secures plate-bone contact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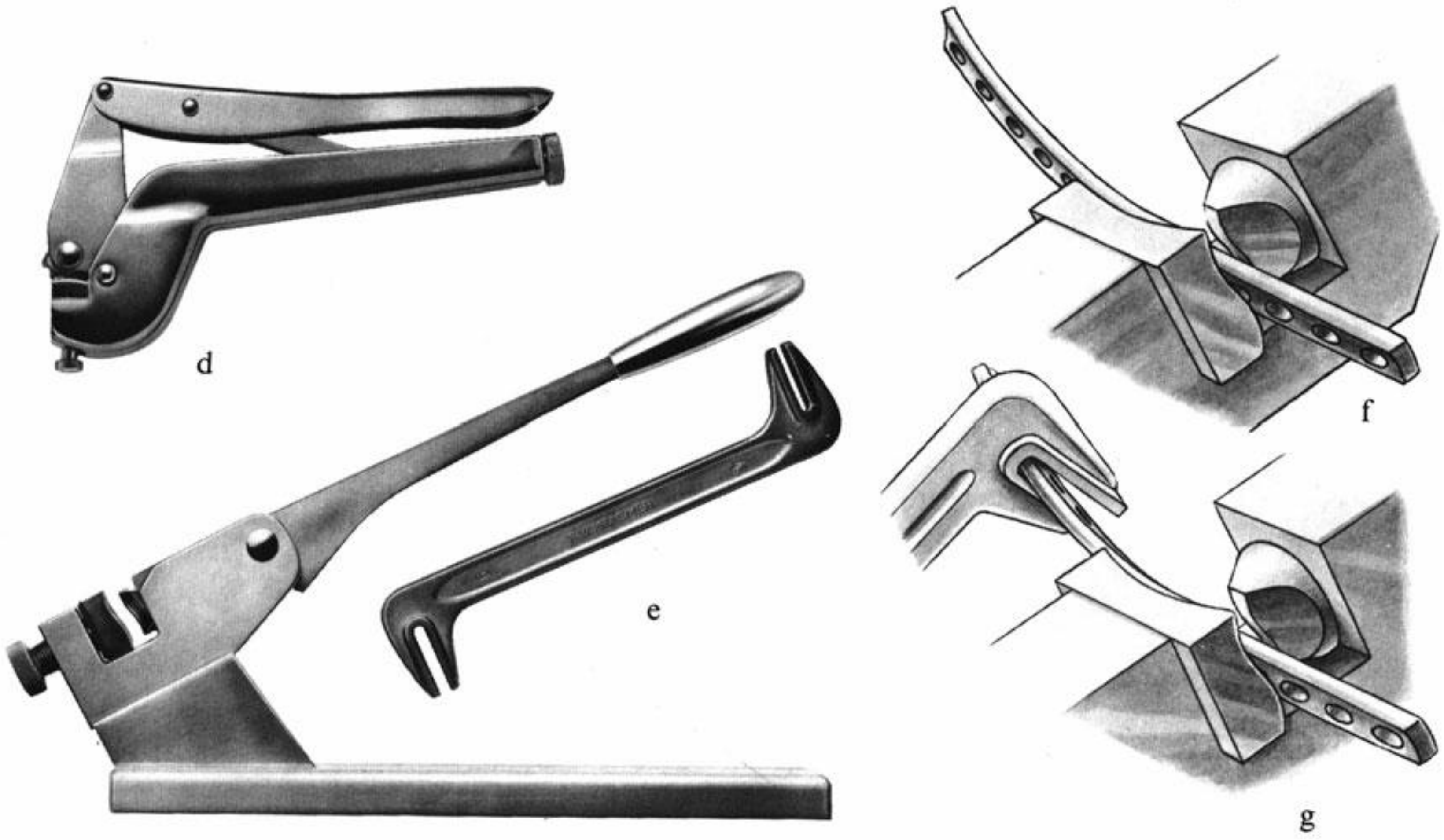
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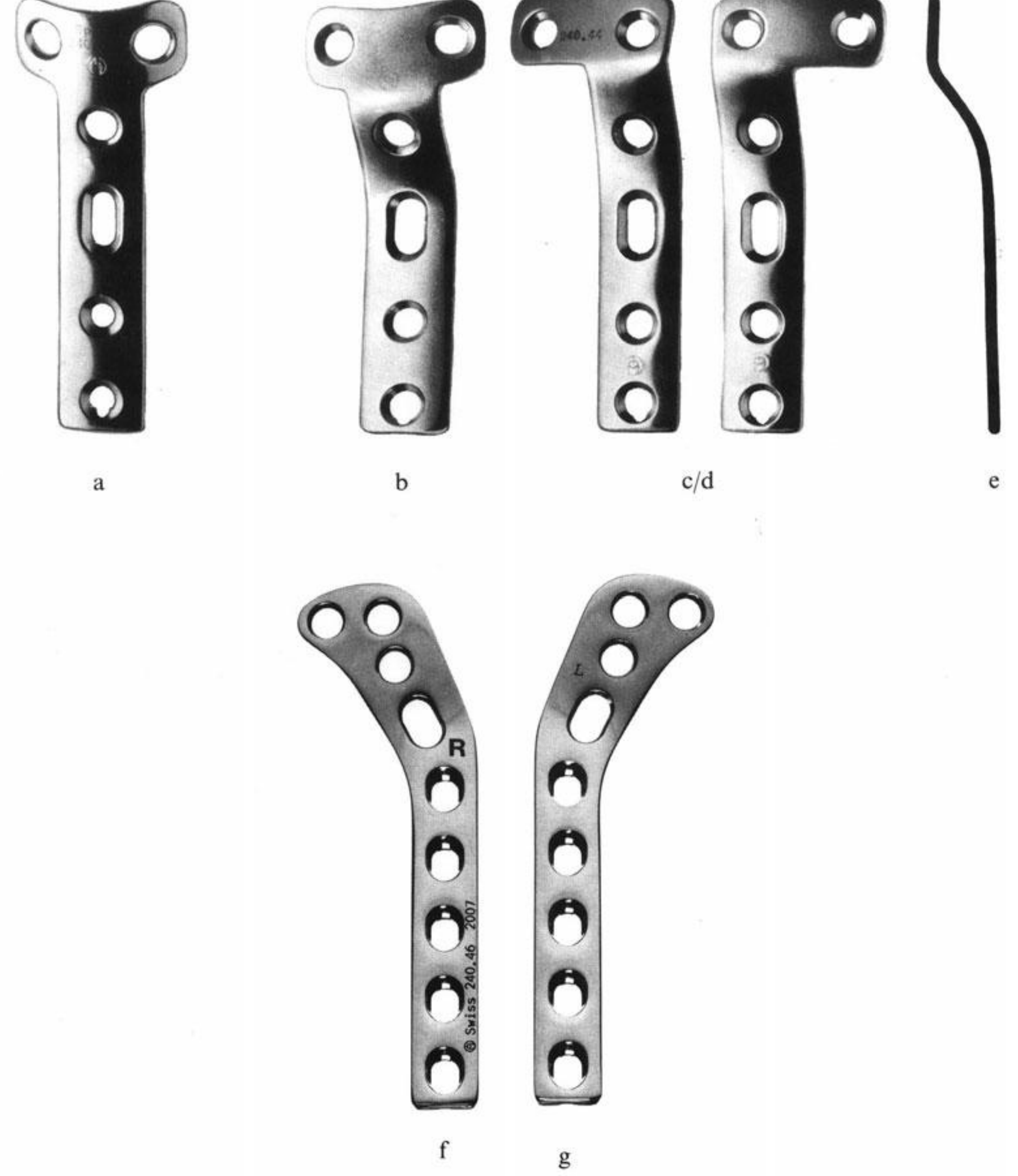
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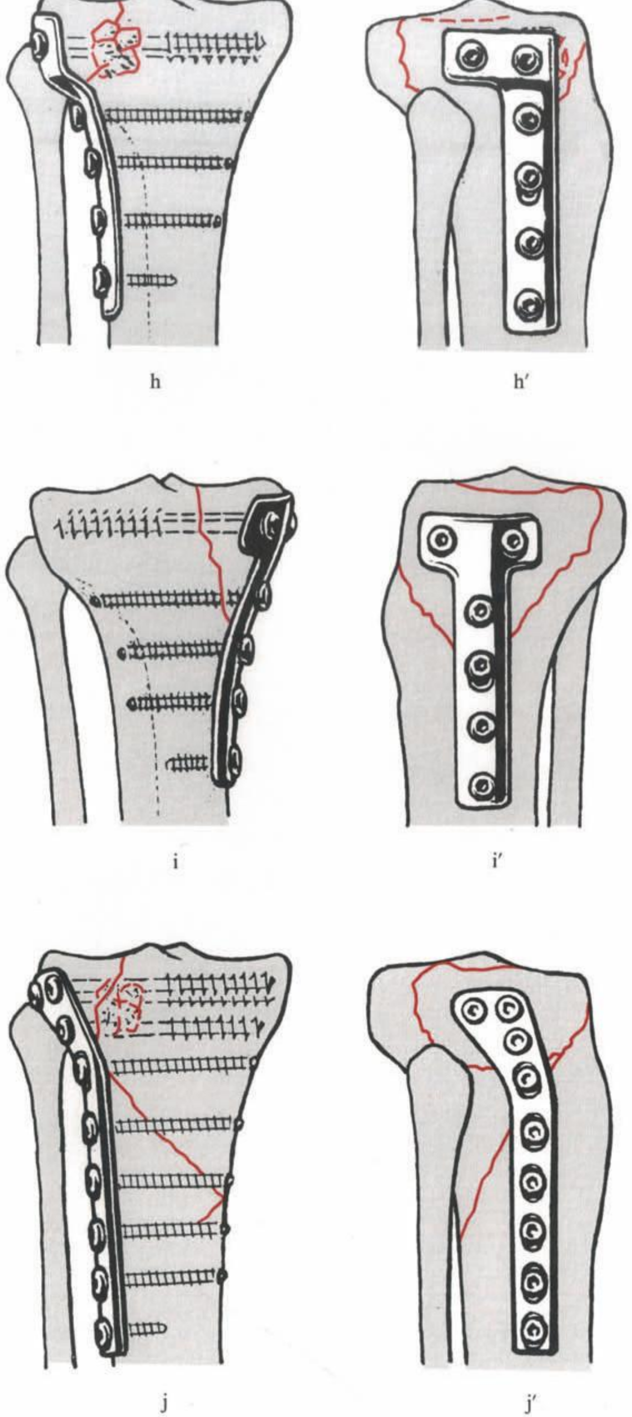
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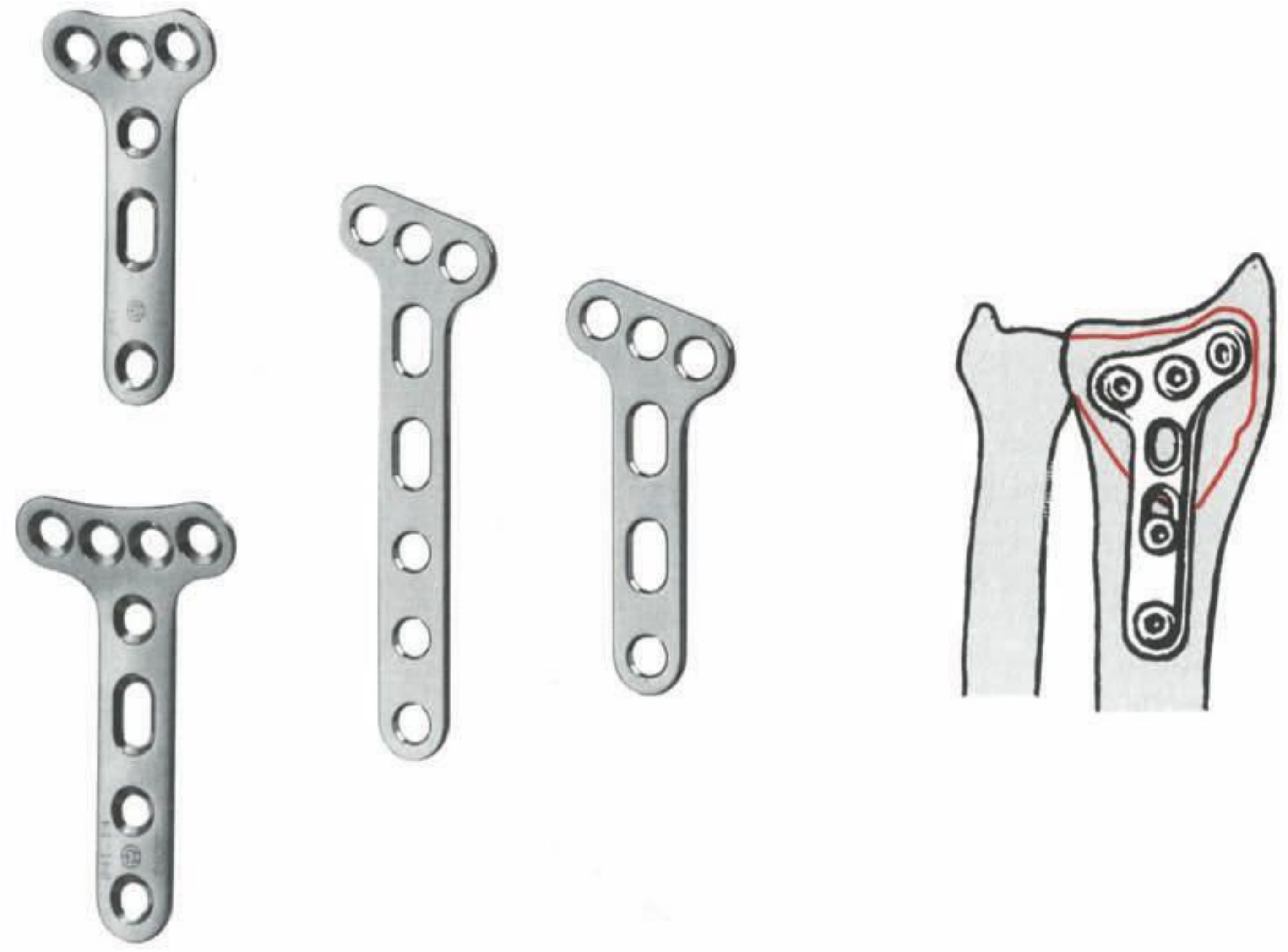
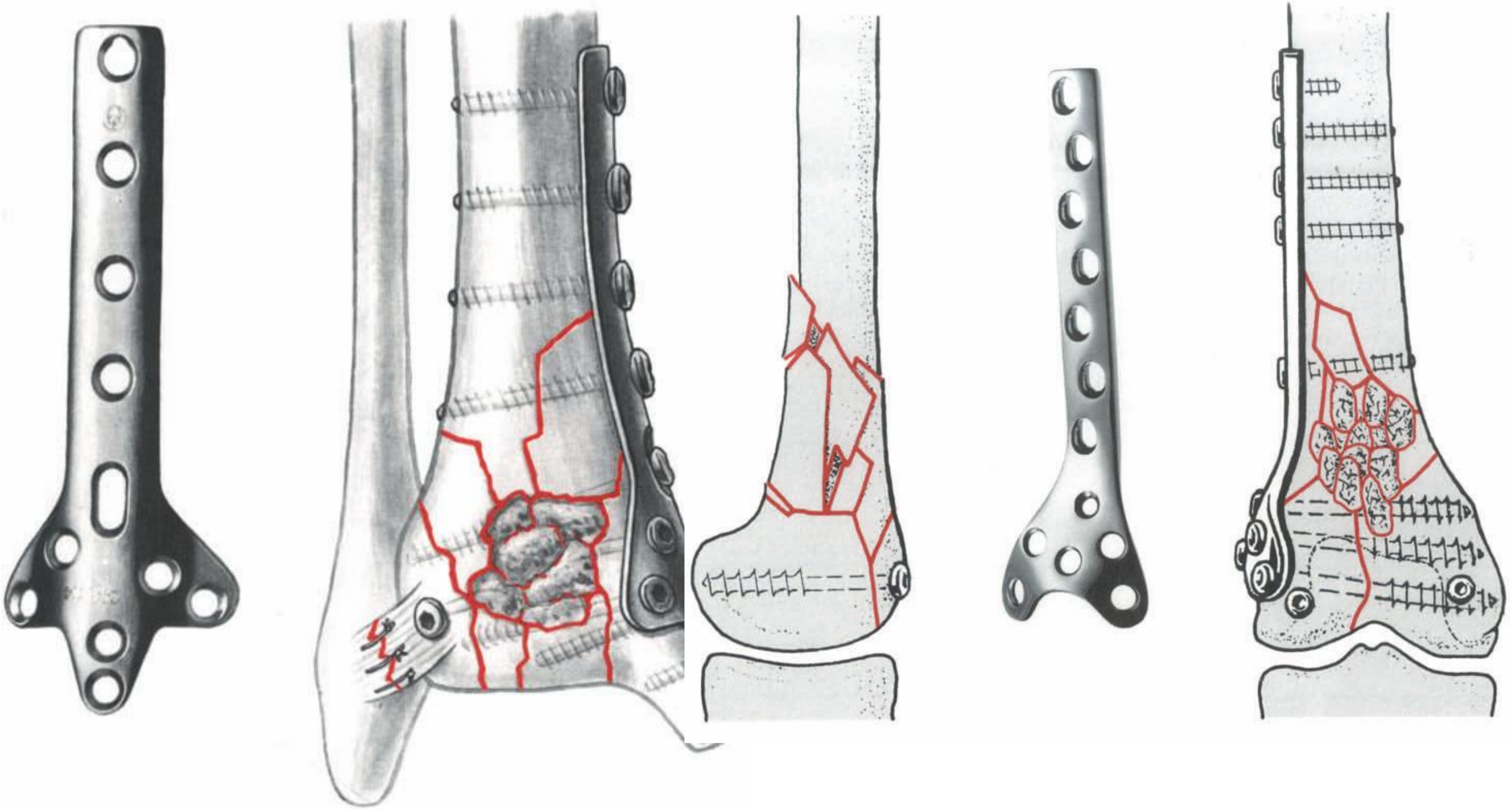


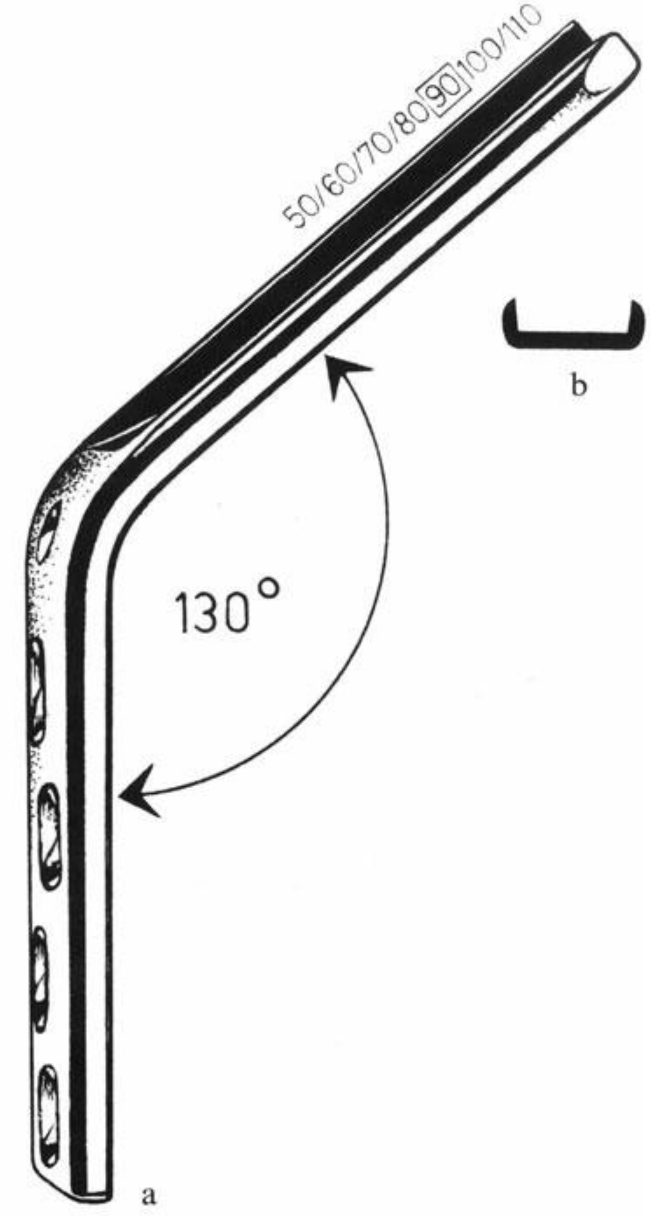


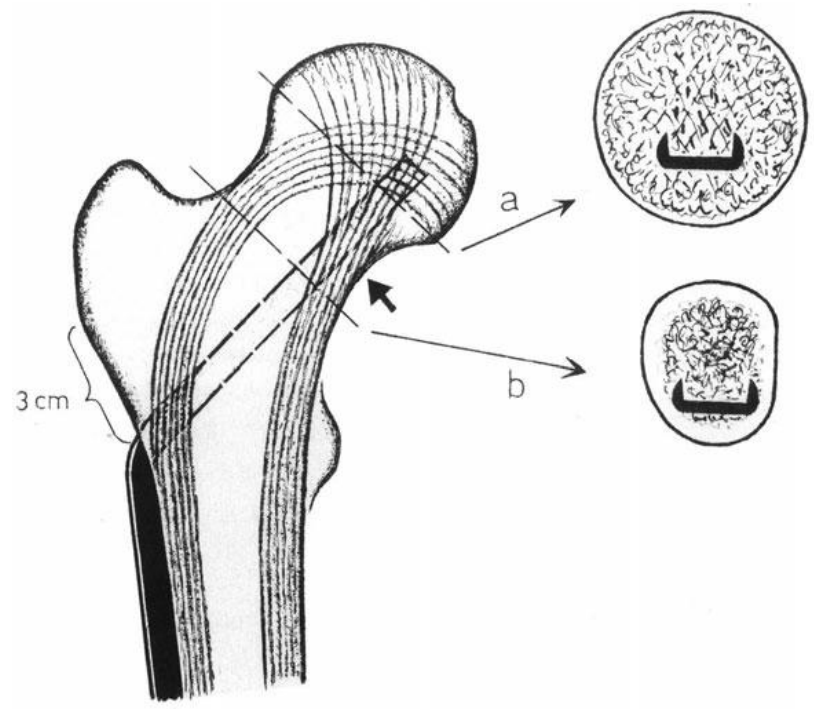
The 130° angle plates.

a The standard 130° blade plates used for the fixation of intertrochanteric and occasionally for subtrochanteric

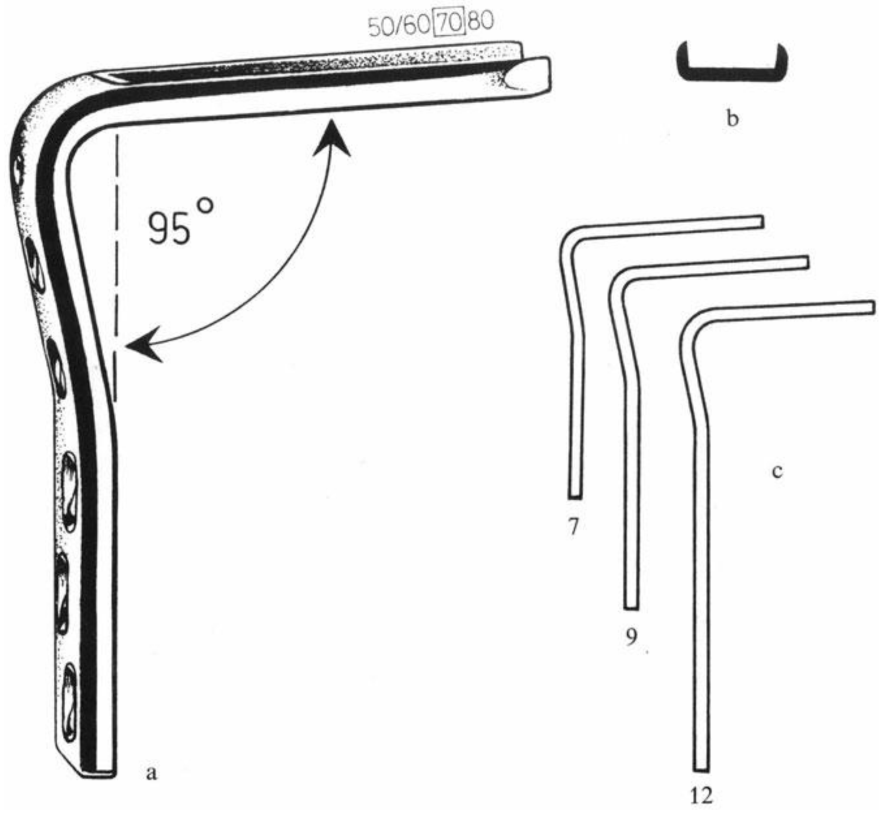
fractures.

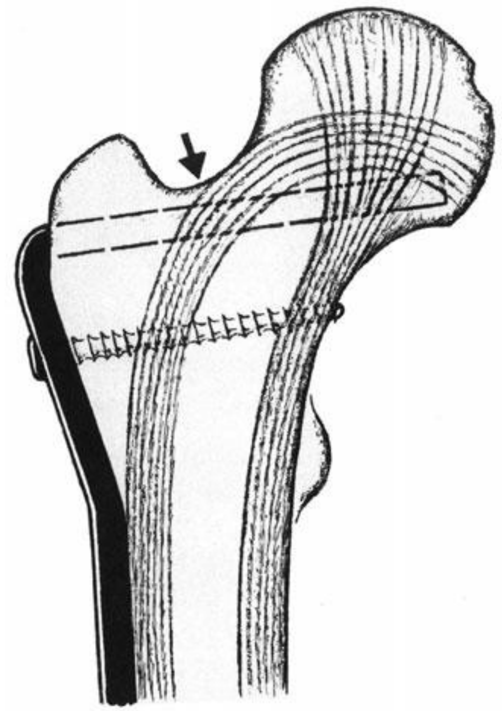
U profile of the blade





The Angled Plates for the Proximal and Distal Femur



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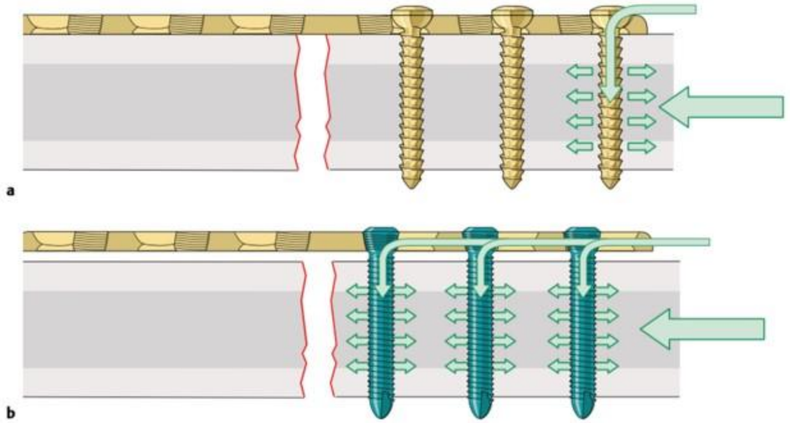
Locking plates

- Can be used as a regular plate to perform the same functions
- Can be used as an internal fixator without compressing the periosteum
- Locking plate/screws: biomechanical advantage
  - Load distribution along the whole construct
  - Higher forces required for failure



The locking compression plate (LCP)

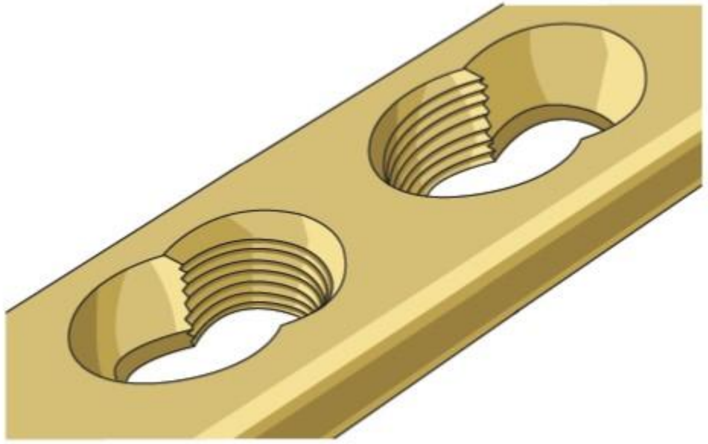
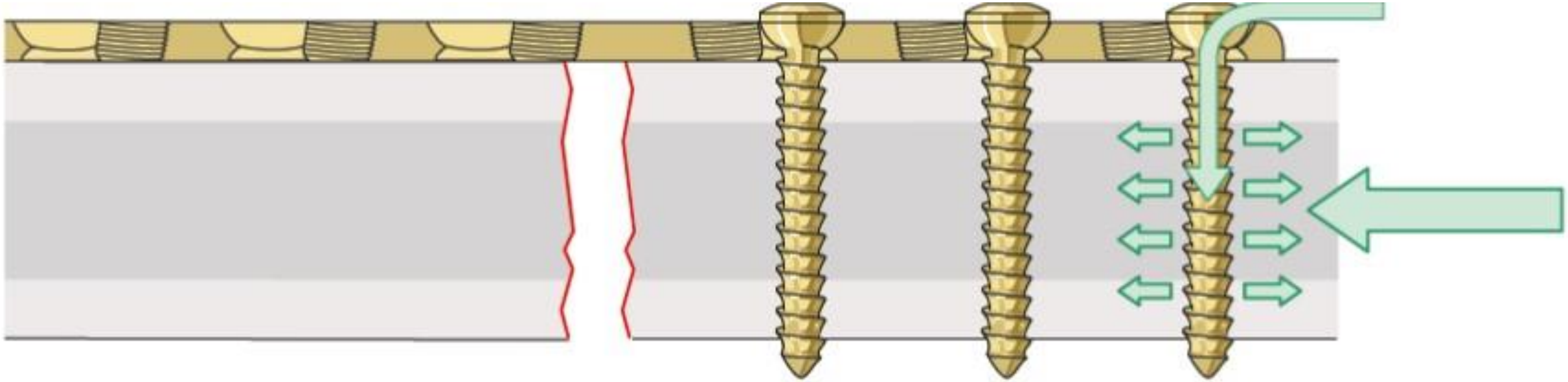
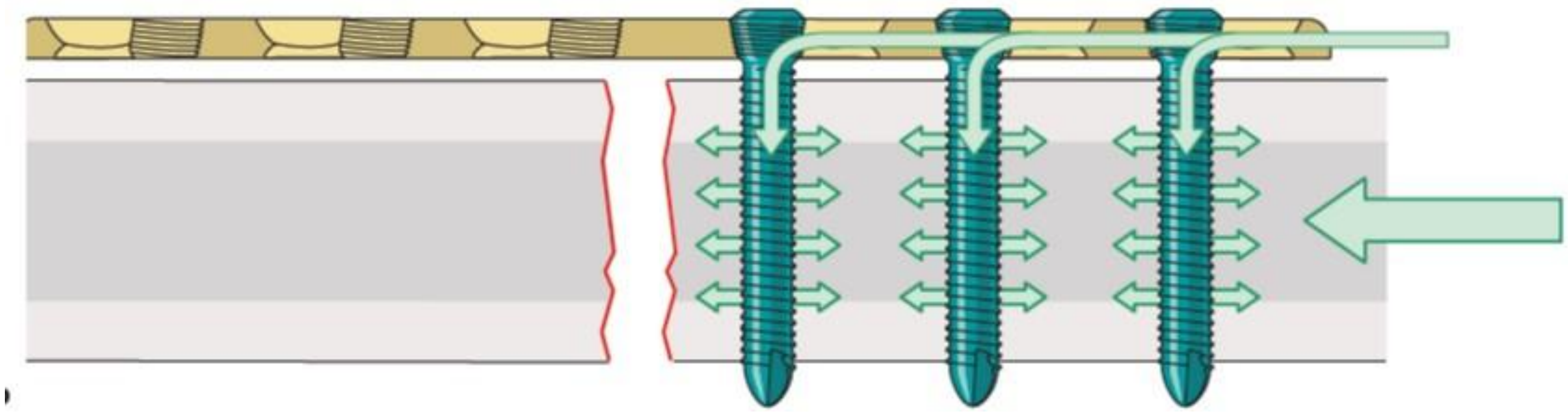


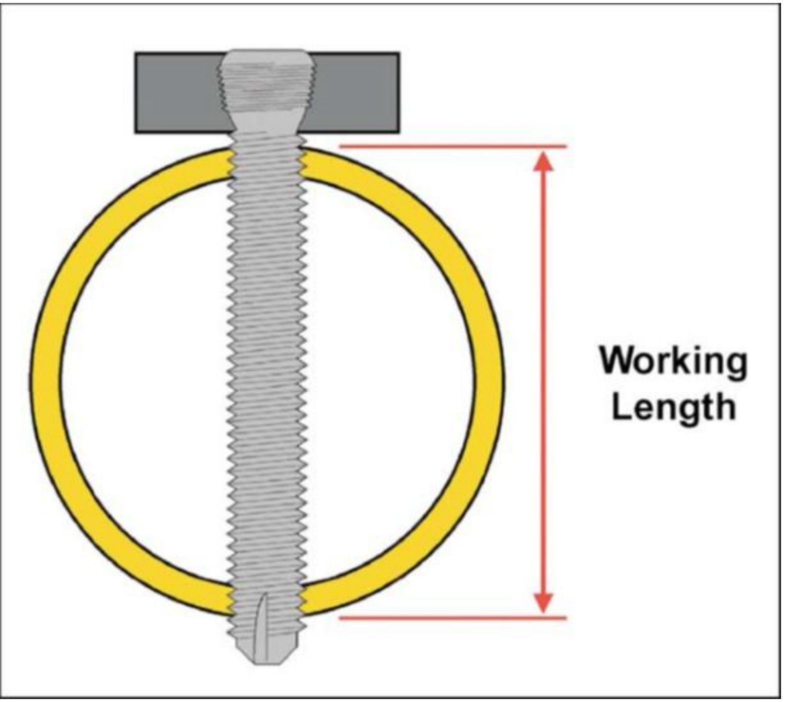
Fig 3.2.2-11 The LCP combination hole (combi-hole) allows conventional and locking head screws to be placed into the same implant but not into the same hole at once.

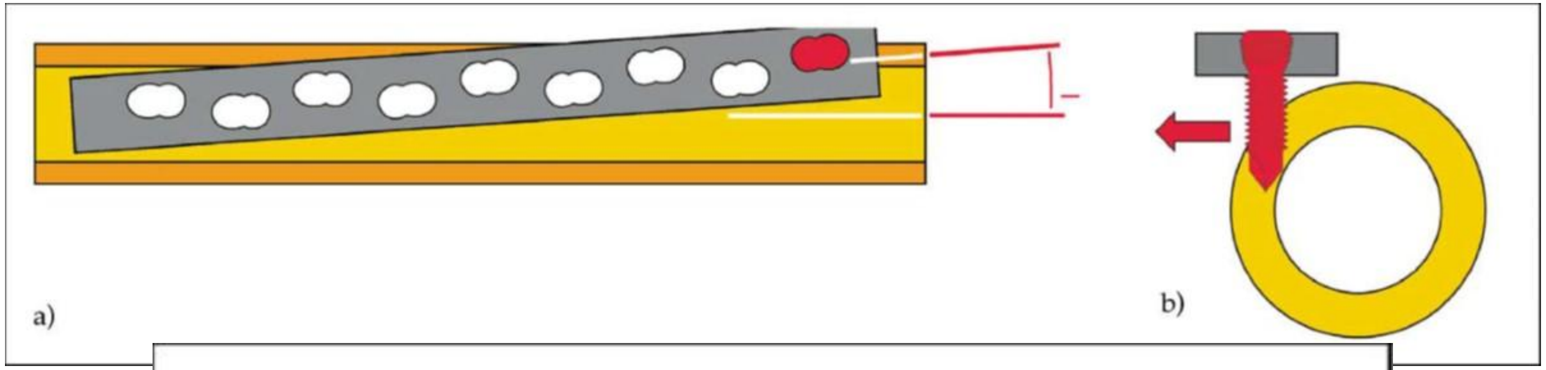


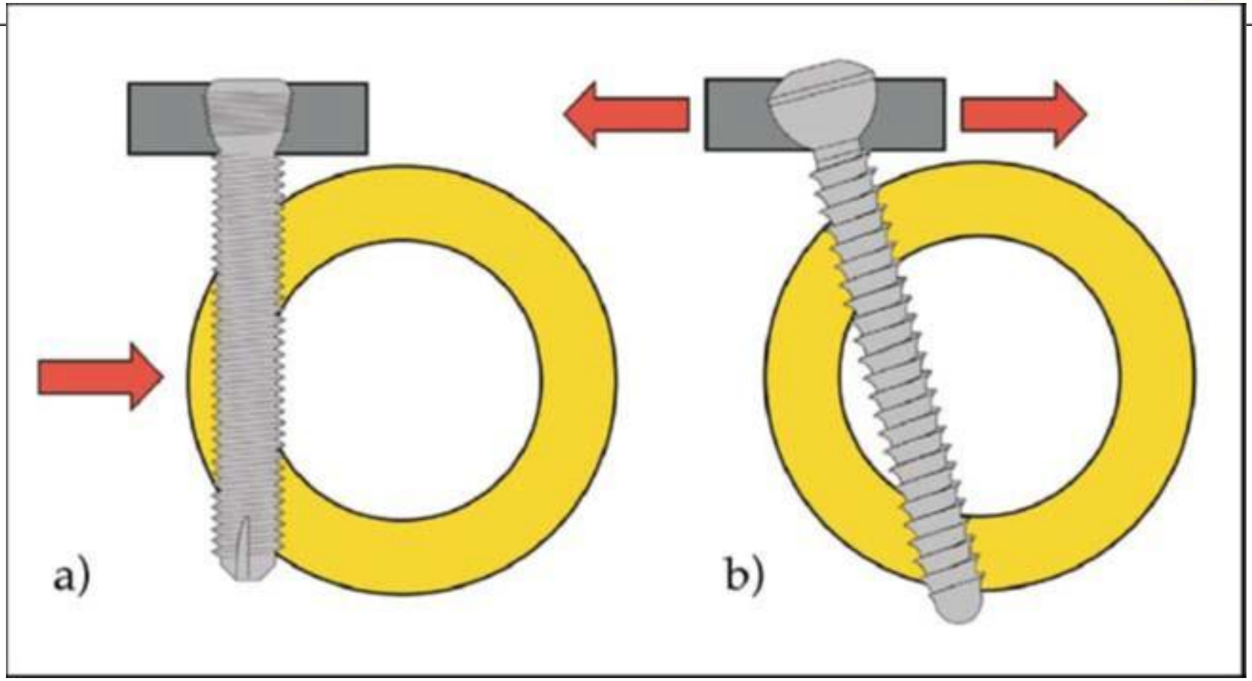
Because a conventional screw head is allowed to toggle during loading, energy is dissipated at the bone-screw interface farthest from the fracture. Energy is concentrated at this level, shielding additional screws from load initially



In locking plates, the angular-stable screws (LHS) prevent load concentration at a single bone-screw interface by distributing load more evenly

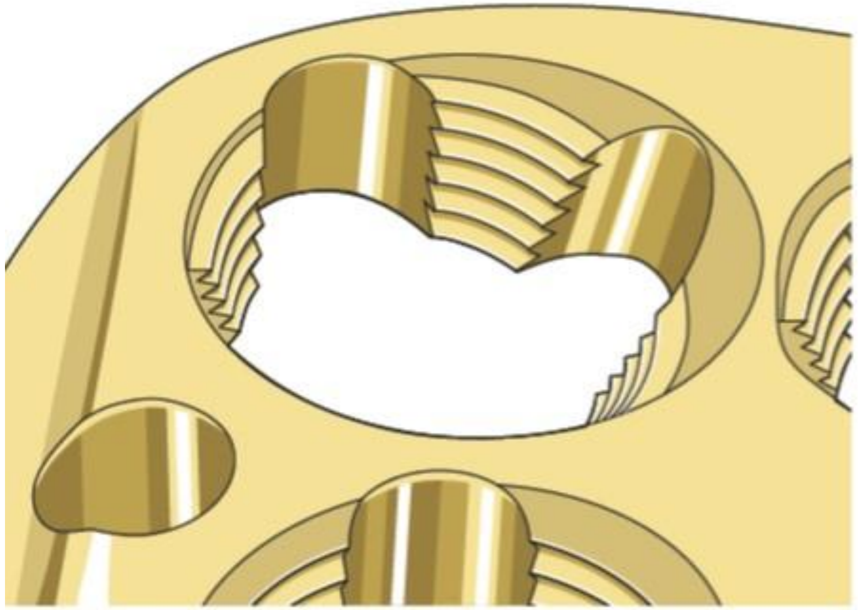


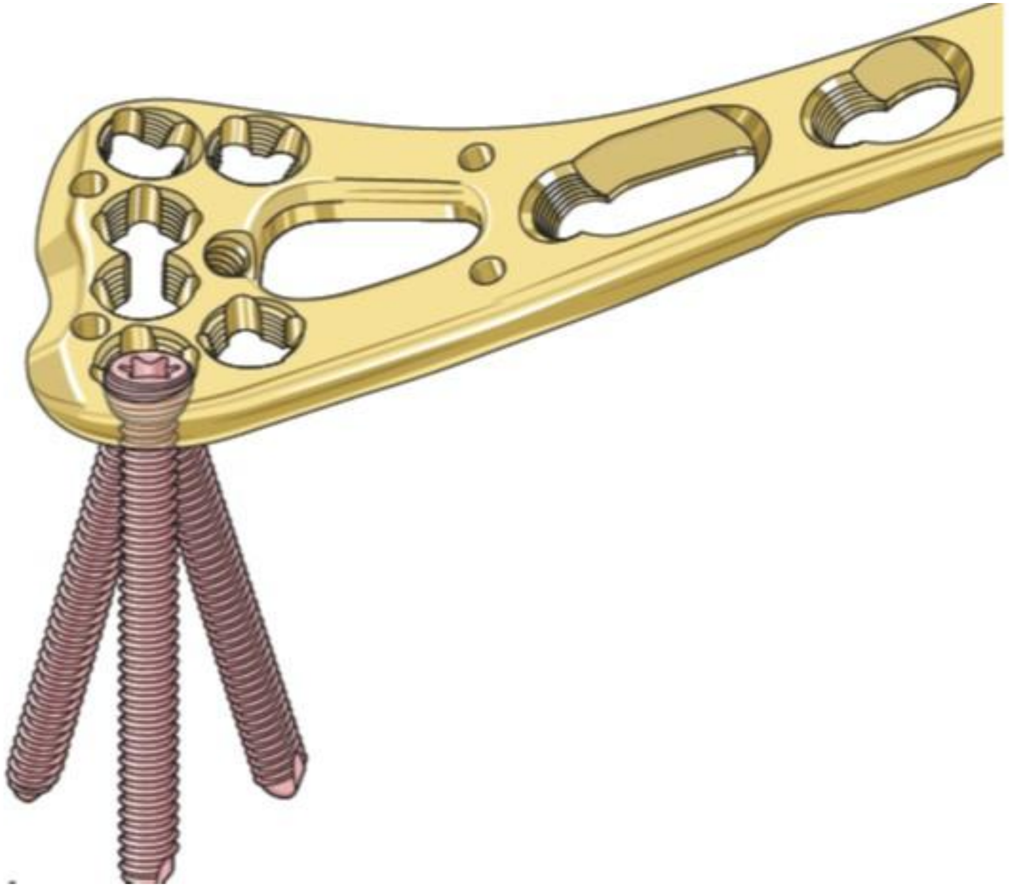




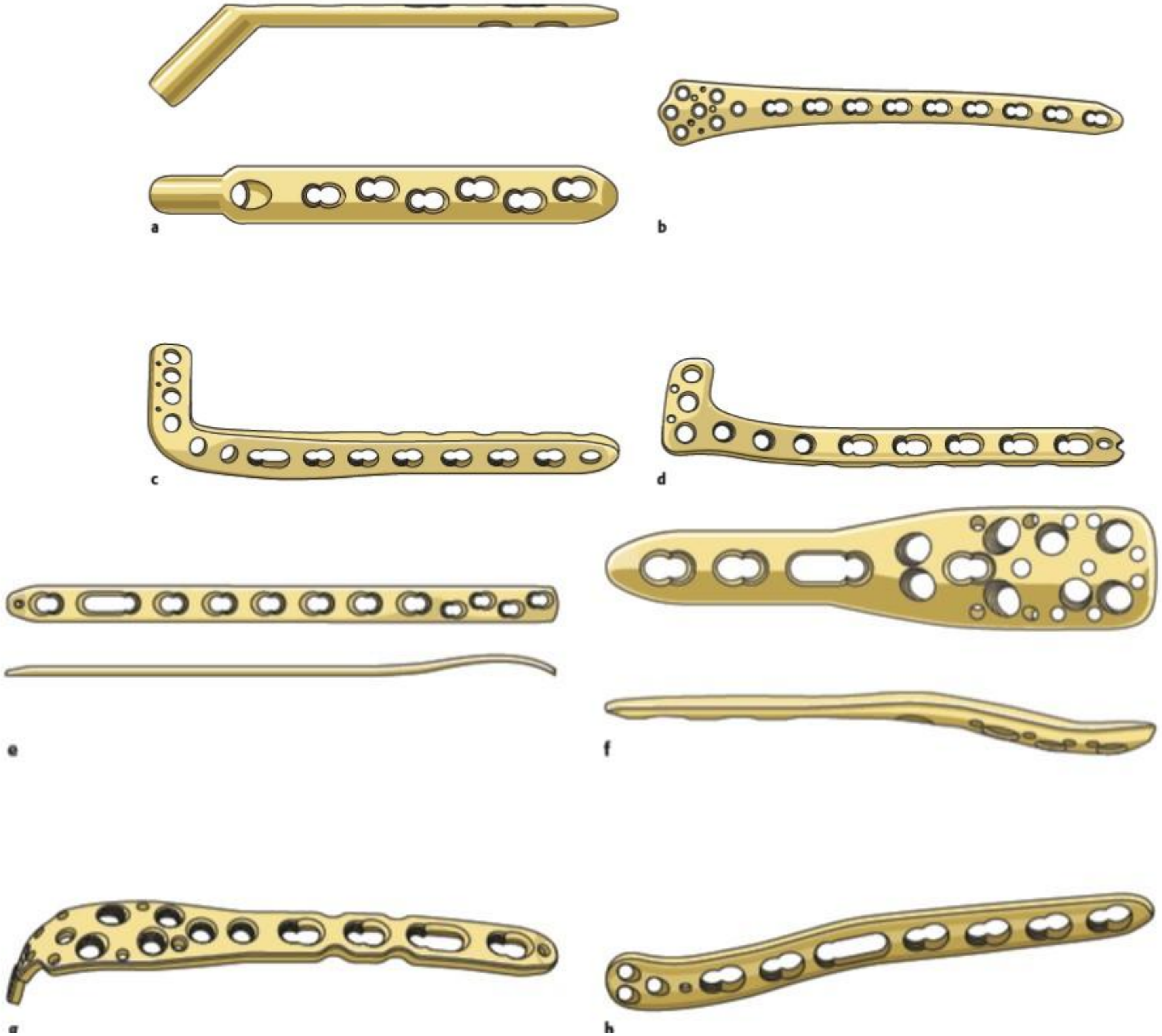
Gautier et al.: Guidelines for the clinical application of the LPC

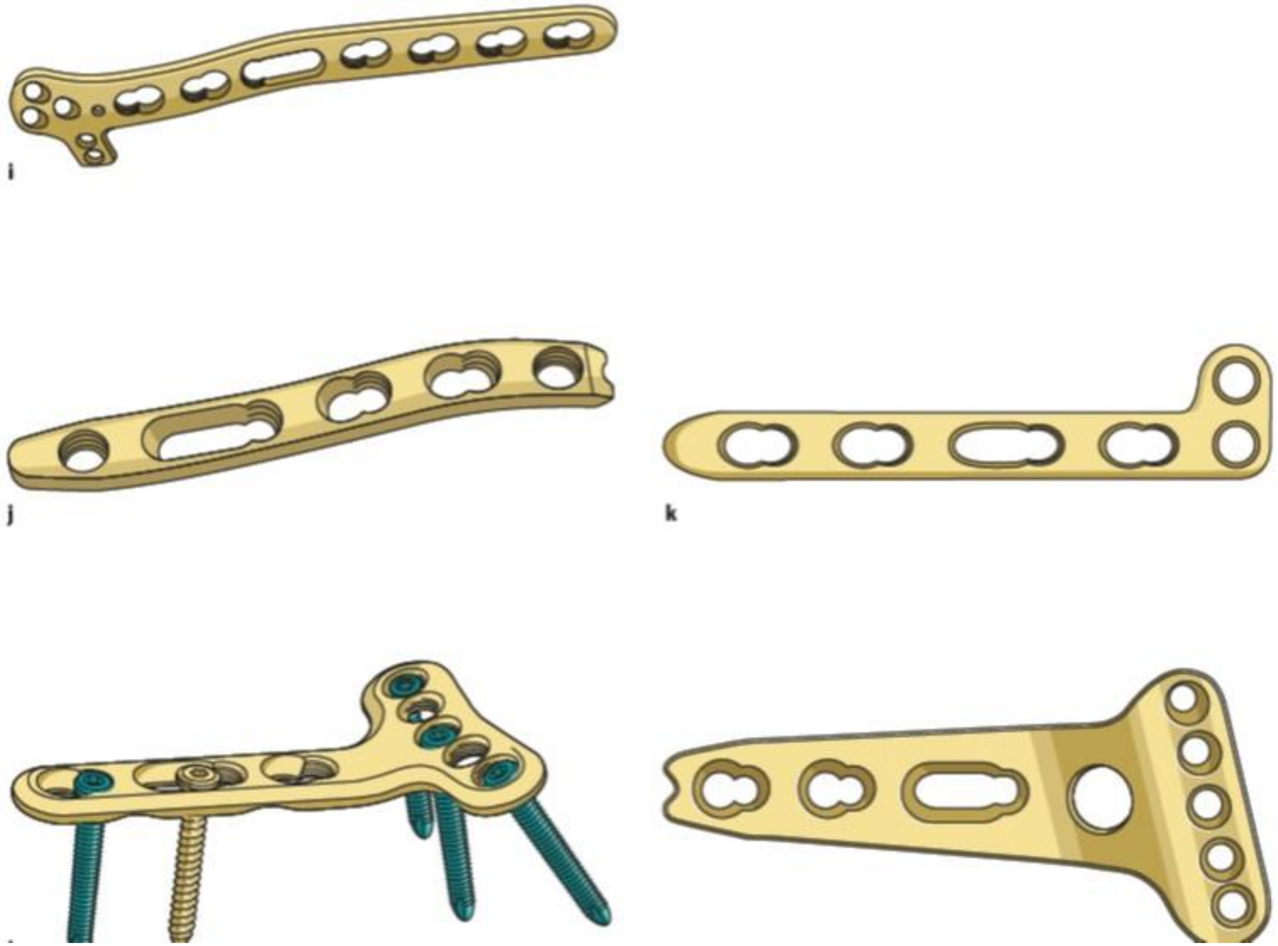
most recent development in locking plates is polyaxial screw technology





Special plates




i
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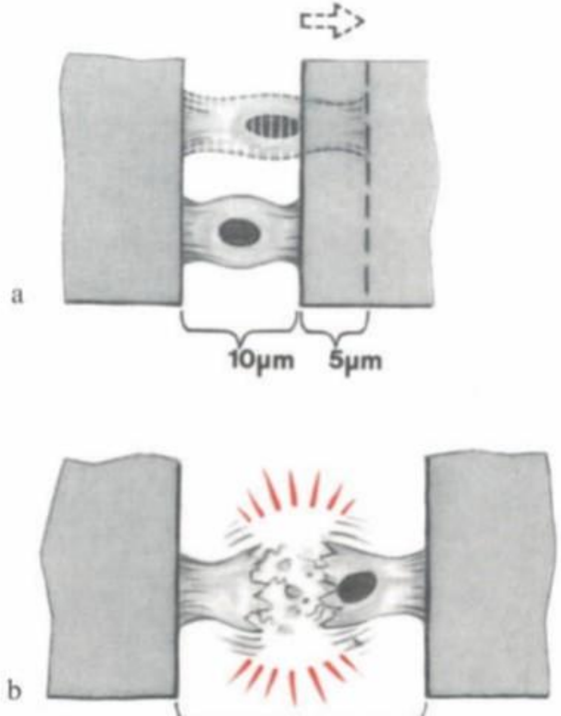
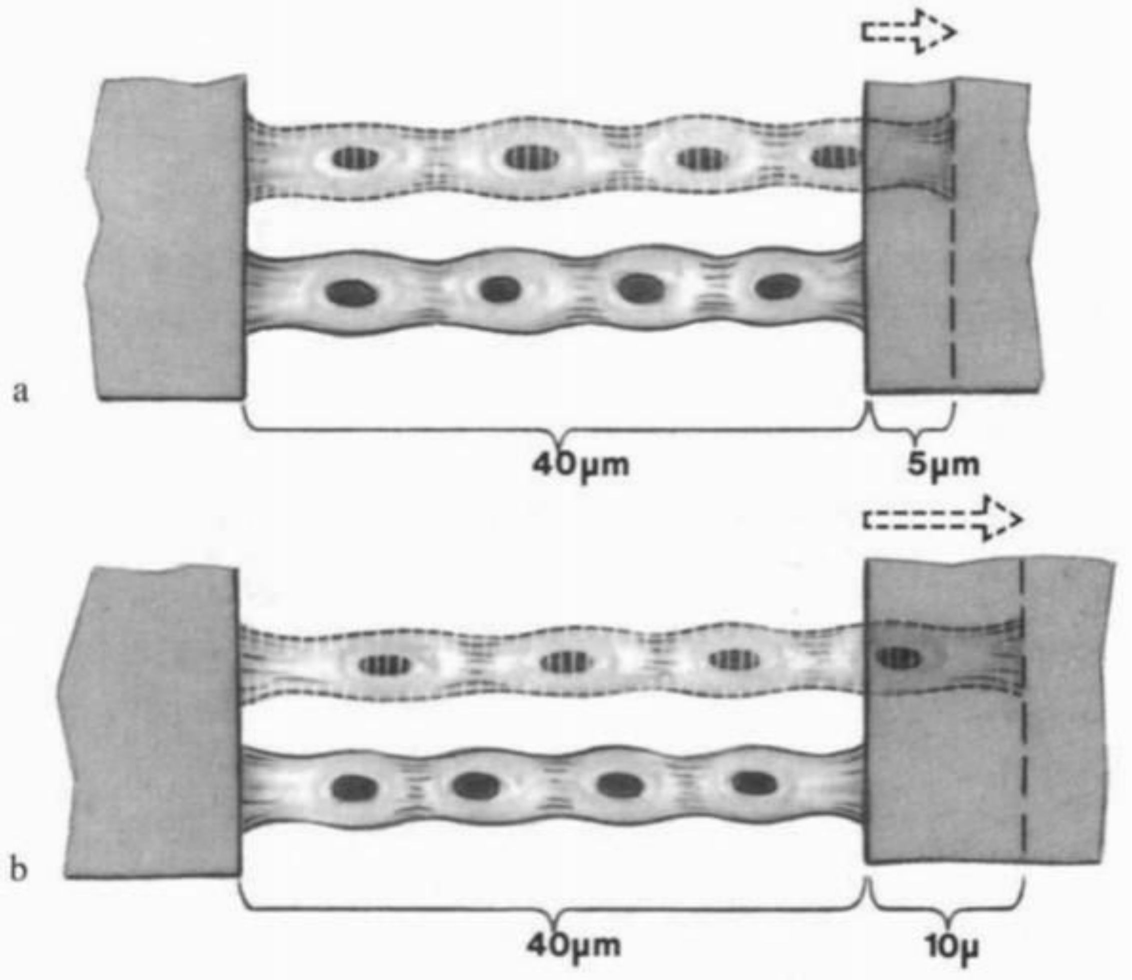
Biology of Bone Healing

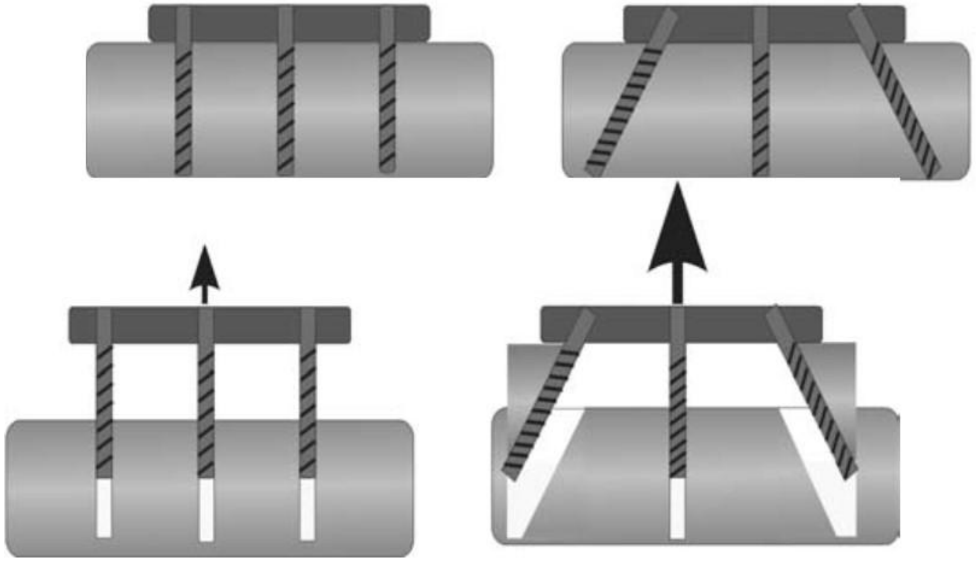
The deformation of the cells or tissues is critical. It depends not only upon the degree of displacement (t5 L) of the fragments (instability), but also (and more importantly} upon the initial width of the fracture gap (L). For very small gaps (e.g., smaller than 0.1 mm) an imperceptible displacement (0.1 mm) may result in very high strain (> 100%) of any one individual tissue element, for example, the cell

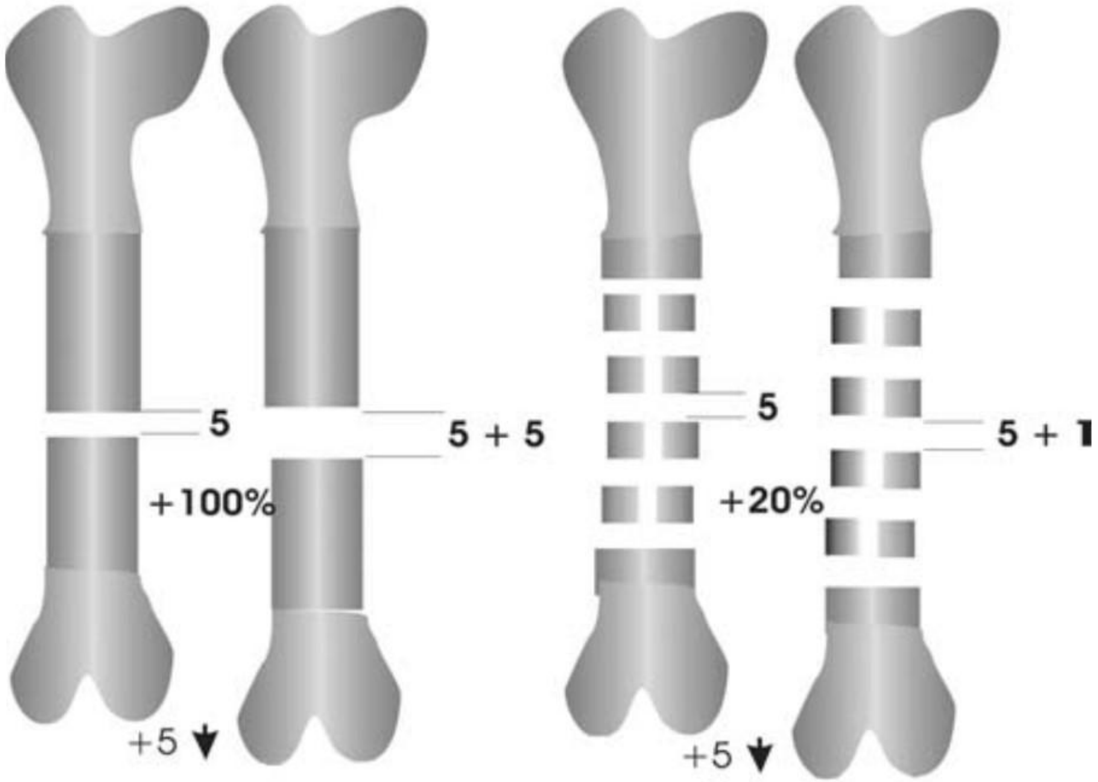
A small displacement (5 !liD) in a small gap between the fragments (here about one cell layer thickness, ~ 10 !liD) results in a strain of 50%.



A small displacement (5 !liD, same as in Fig. 1.9a) within an initially wide gap (40 11m) results in strain (~ 12%) which is tolerated by dense fibrous tissue.







Stephan M. Perren

Any nonlocking
plate can be used to provide any of the six key functions of a plate

The surgeon, not the designer of the plate, determines how a plate will function and how it will be applied

.

The LC-DCP can be used to provide six different biomechanical
functions:

- Compression
- Protection
- Buttress
- Tension band
- Bridging
- Reduction

Types of Mechanical Load

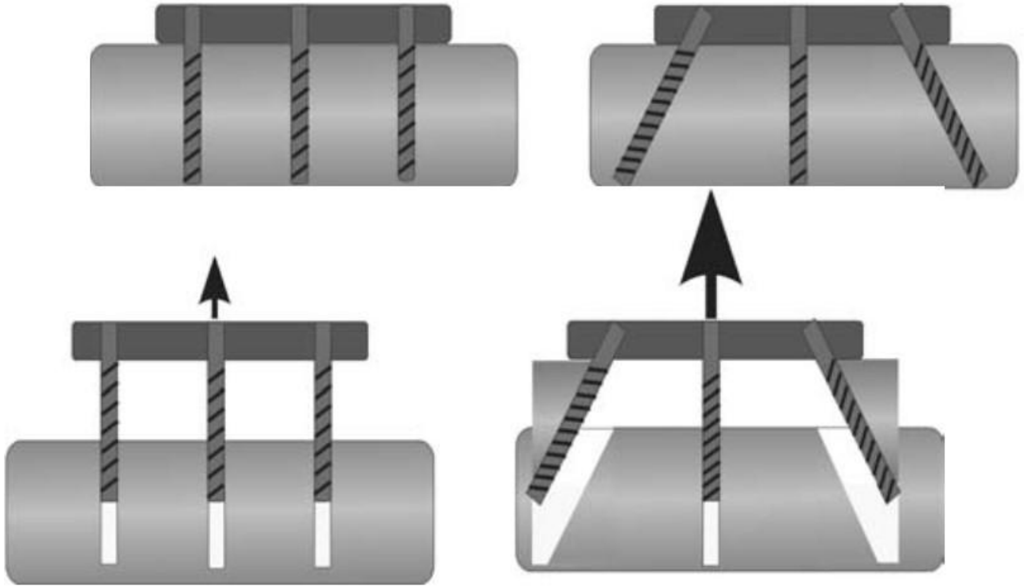
Load may or may not change (appreciably) with *time.* A load which does not change

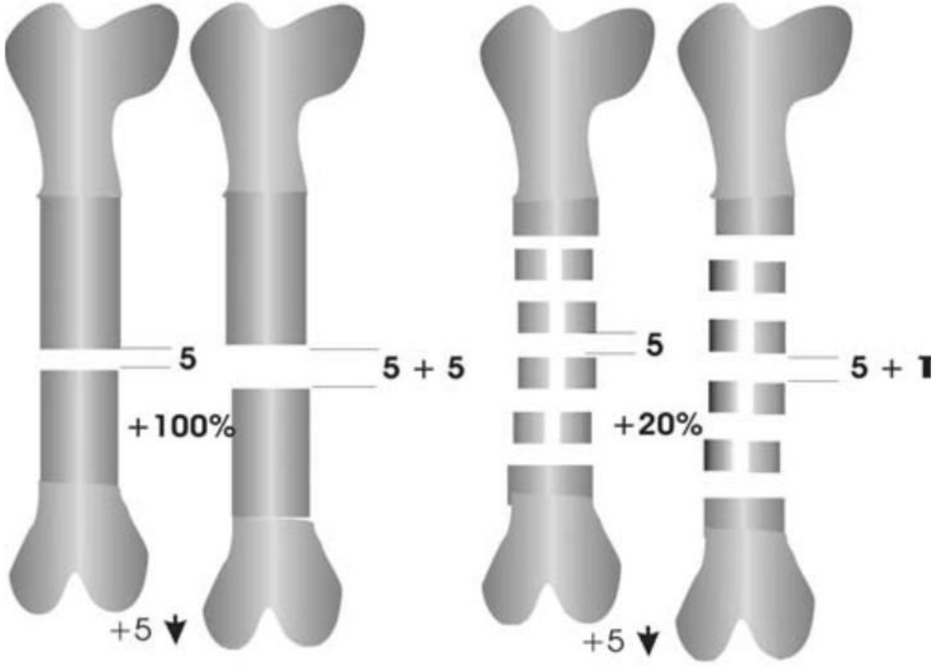
with time is called static, [8] while periodically or intermittently changing load is dynamic

in nature. The compression exerted by an implant applied under tension is static. The

forces generated by the function of the limb (e.g., locomotion) are dynamic or functional

forces.





Stephan M. Perren

Plates in fracture fixation

Intraarticular fractures require anatomical reduction and absolute stability

fixation of the Metaphysis . short distal or proximal fragment,

Diaphyseal fractures of long bones are often treated with intramedullary nailing but good indications for plating include the need for anatomical reduction (eg, forearm and fibular shaft

may be preferred to external fixation in some polytrauma patients and in some cases of nonunion, especially in the presence of deformity

Plates in fracture fixation

- Compression plate
- Protection plate
- Buttress plate
- Tension band plate
- Bridging plate
- Reduction

Plate function	Biomechanics	Example of application
Compression	The plate produces compression at the fracture site to provide absolute stability.	Simple transverse humeral fracture
Protection	The plate neutralizes bending and rotational forces to protect a lag screw fixation.	Simple oblique radial fracture
Buttress	The plate resists axial load by applying force at 90° to the axis of potential deformity.	Lateral tibial plateau fracture
Tension band	The plate is attached to the tension side of a fracture and converts the tensile force into a compressive force at the cortex opposite the implant.	Olecranon fracture
Bridging	The plate provides relative stability by fixation to the two main fragments, achieving correct length, alignment, and rotation. The fracture site is left undisturbed.	Multifragmentary ulnar fracture
Reduction	The plate assists in the direct reduction and overall position of fracture fragments that is either temporary or definitive. The plates do not harm fracture biology but are needed to provide accurate positioning of fracture fragments as definitive fixation can be achieved.	Multifragmentary proximal tibial fracture

Table 3.2.2-1 The six functions of a nonlocking plate.

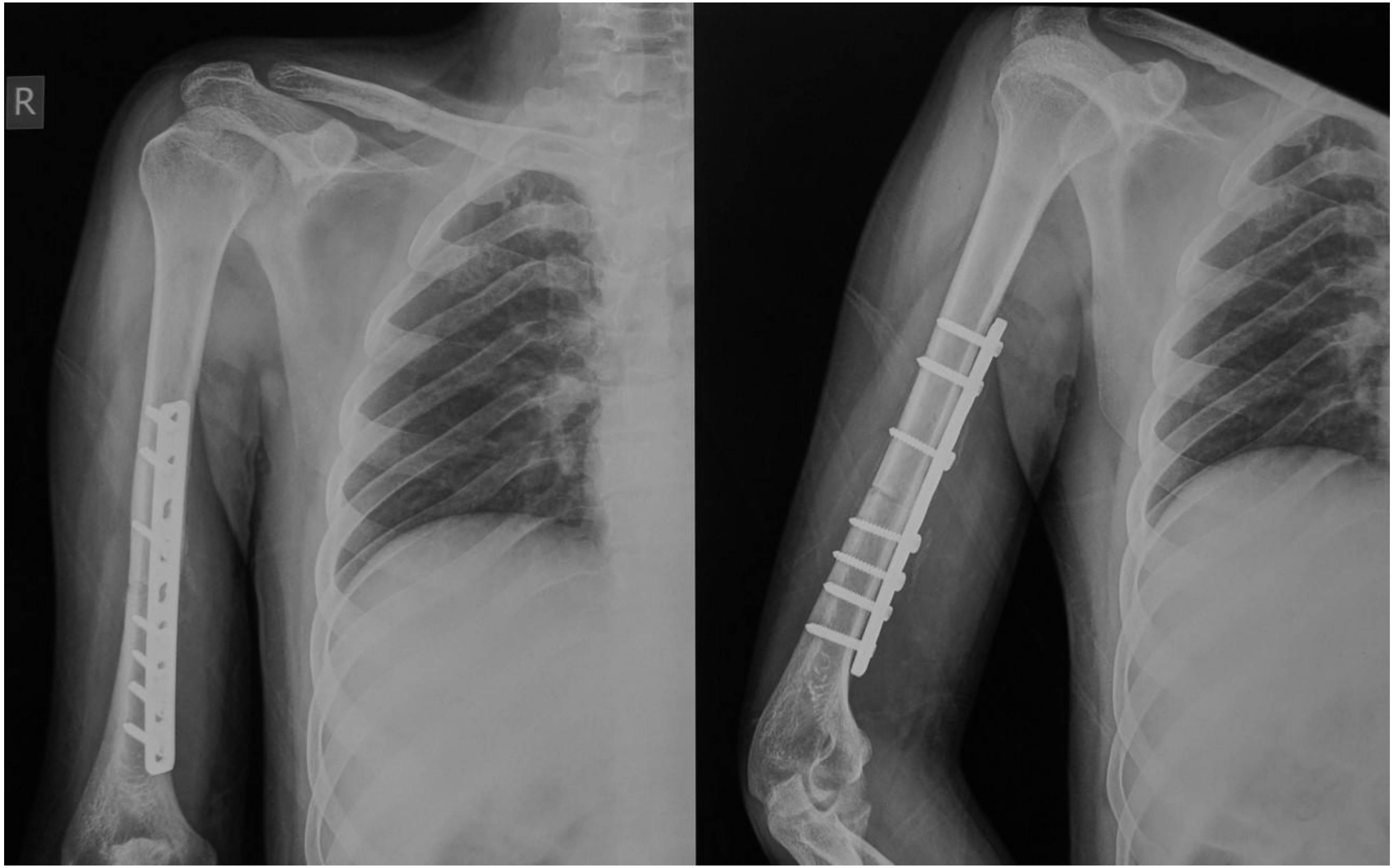
Compression plating

- Dynamic compression principle (DCP)
- Plate over-bending
- Tensioning device

……provides absolute stability – direct bone healing (no callus)

Absolute stability: compression by DCP

Transverse fracture



Neutral position (green end of the guide).

b Compression (golden end of the guide).

c Buttressing (universal drill guide).

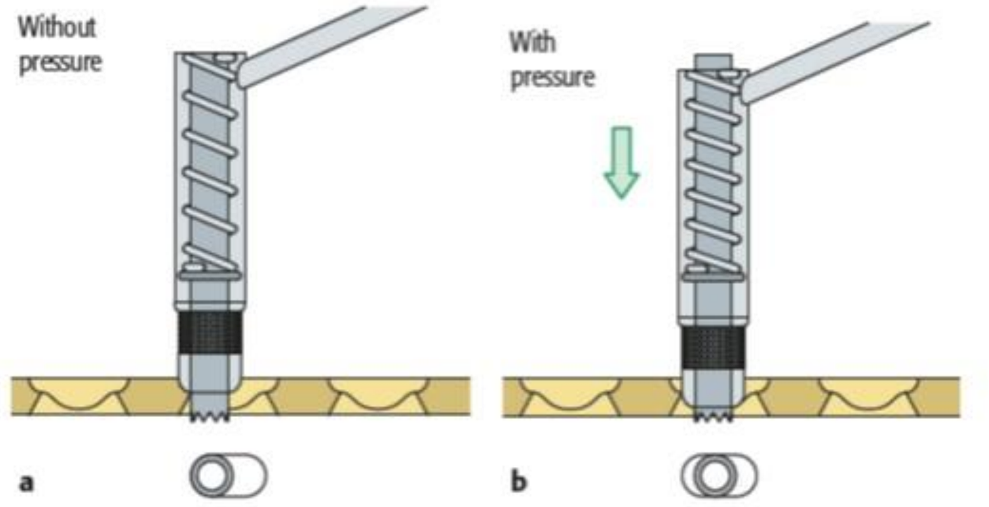
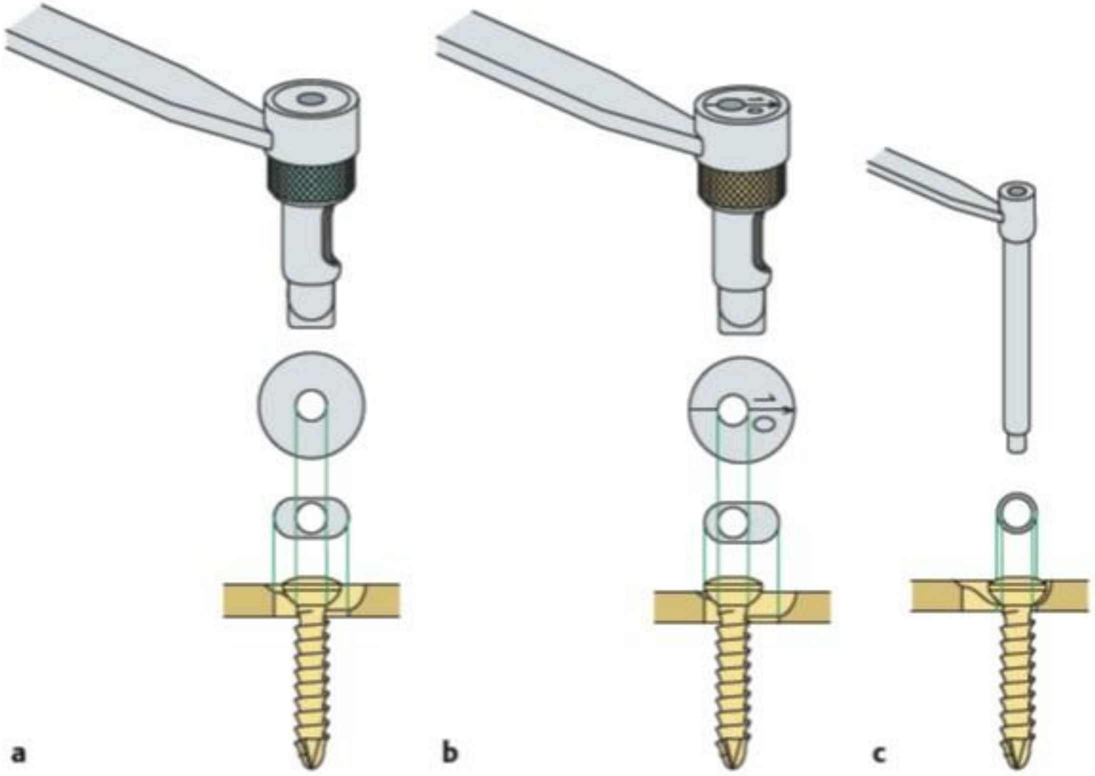
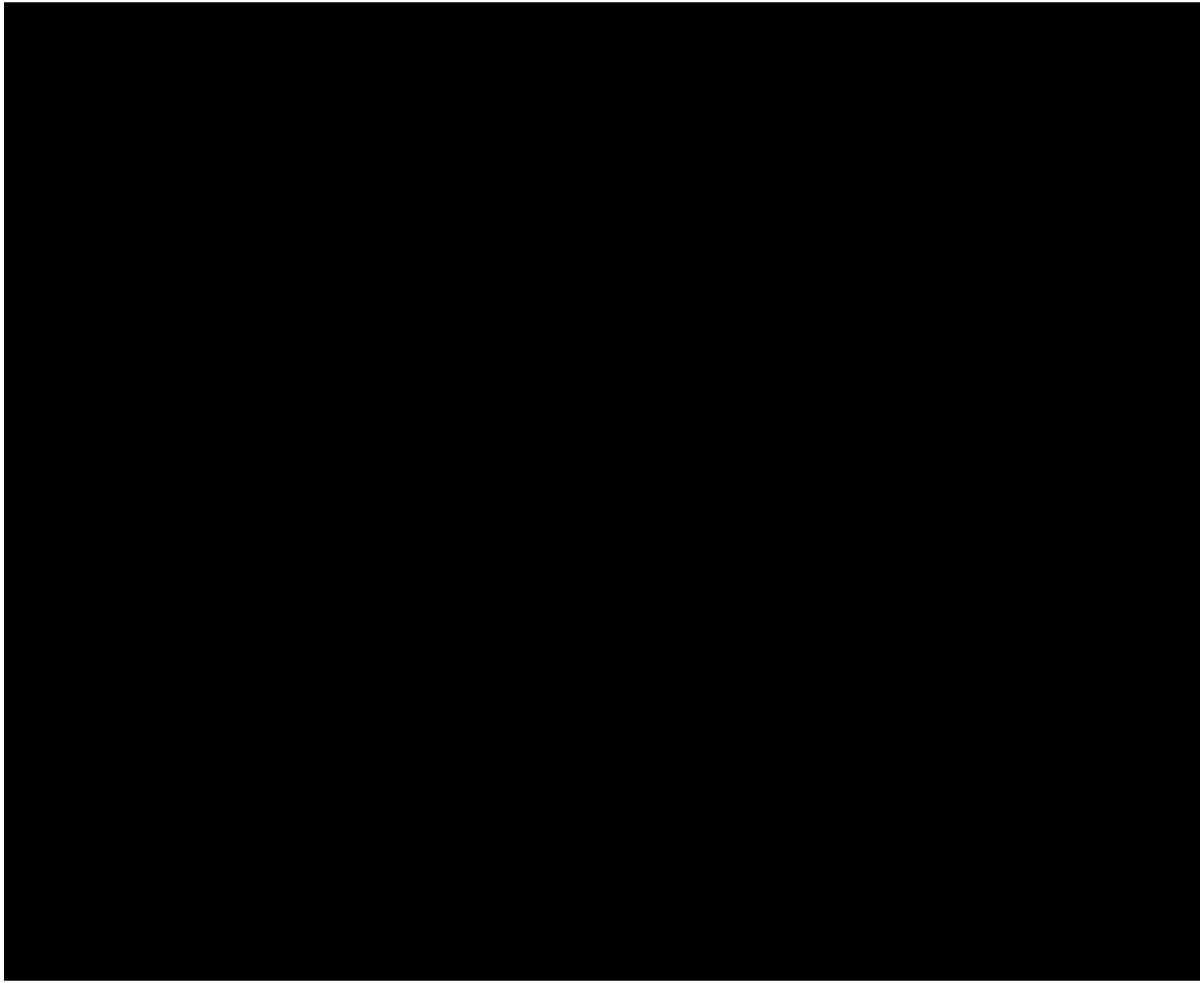
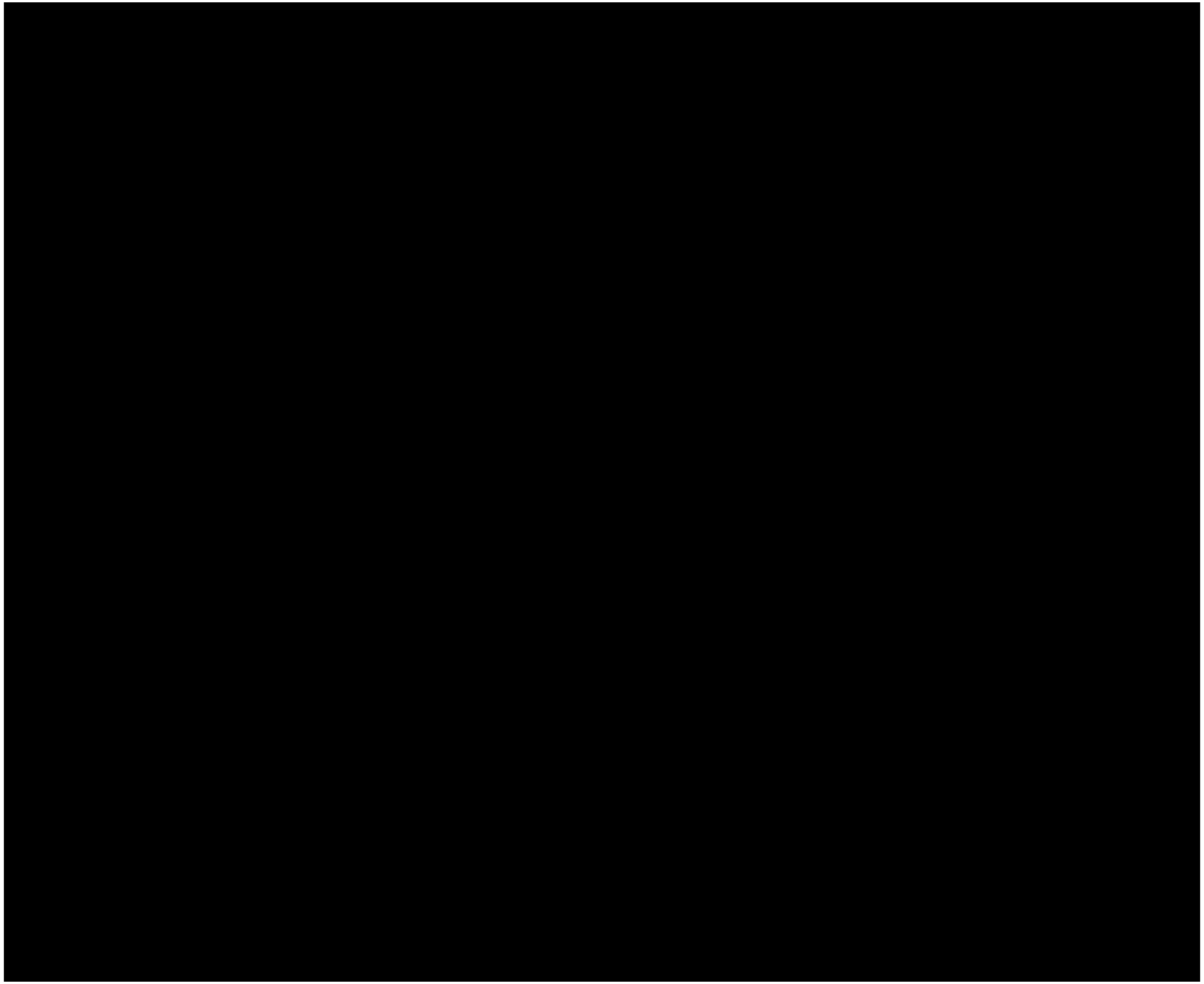
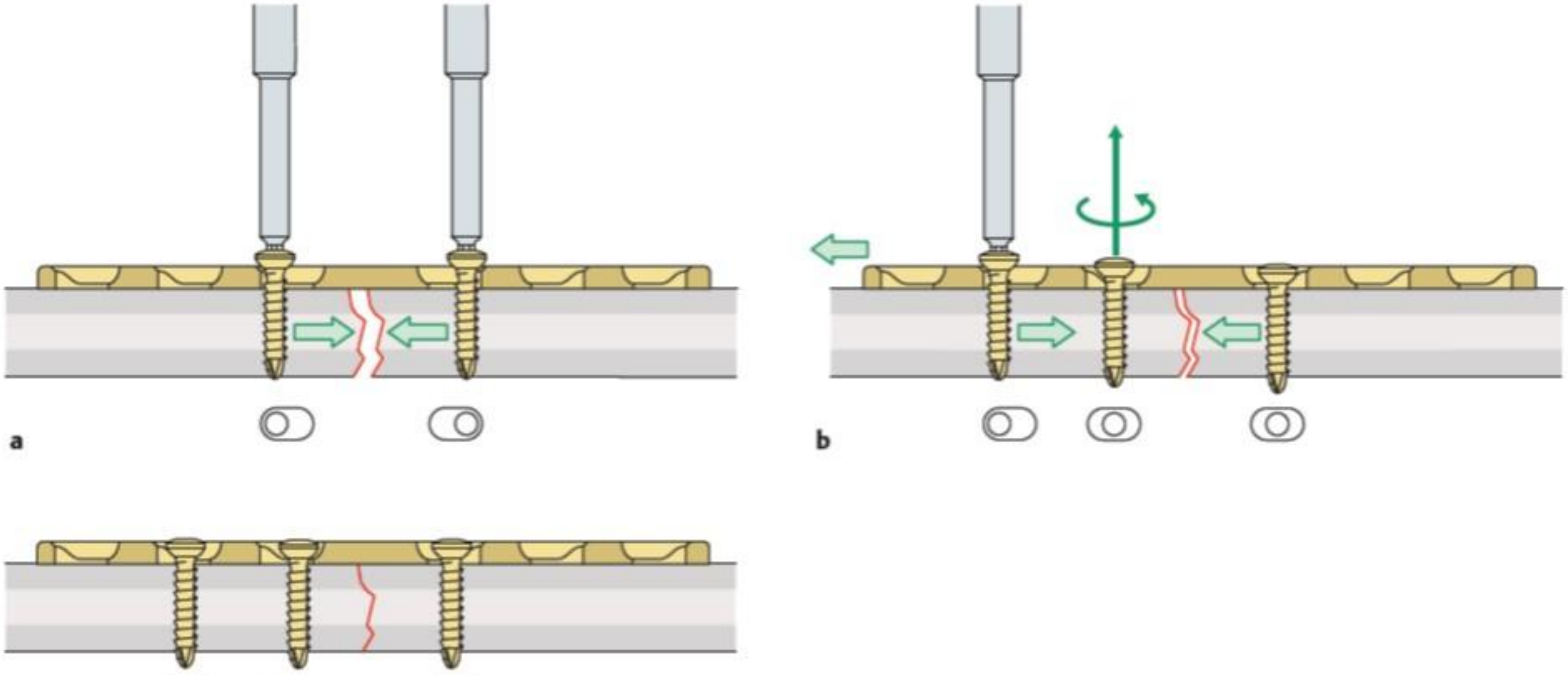


Fig 3.2.2-7a–b Application of the spring-loaded LC-DCP universal drill guide.
a Eccentric position.
b Neutral position.









3.2.2-4a–c

a Inserting one compression screw on either side of the fracture.

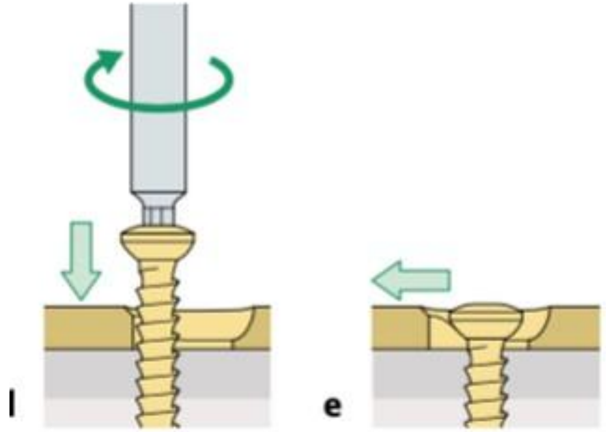
b If after insertion of the two compression screws there remains a fracture gap, a third eccentrically placed screw may be inserted.
Before this screw is tightened, the first screw has to be loosened to allow the plate to slide.

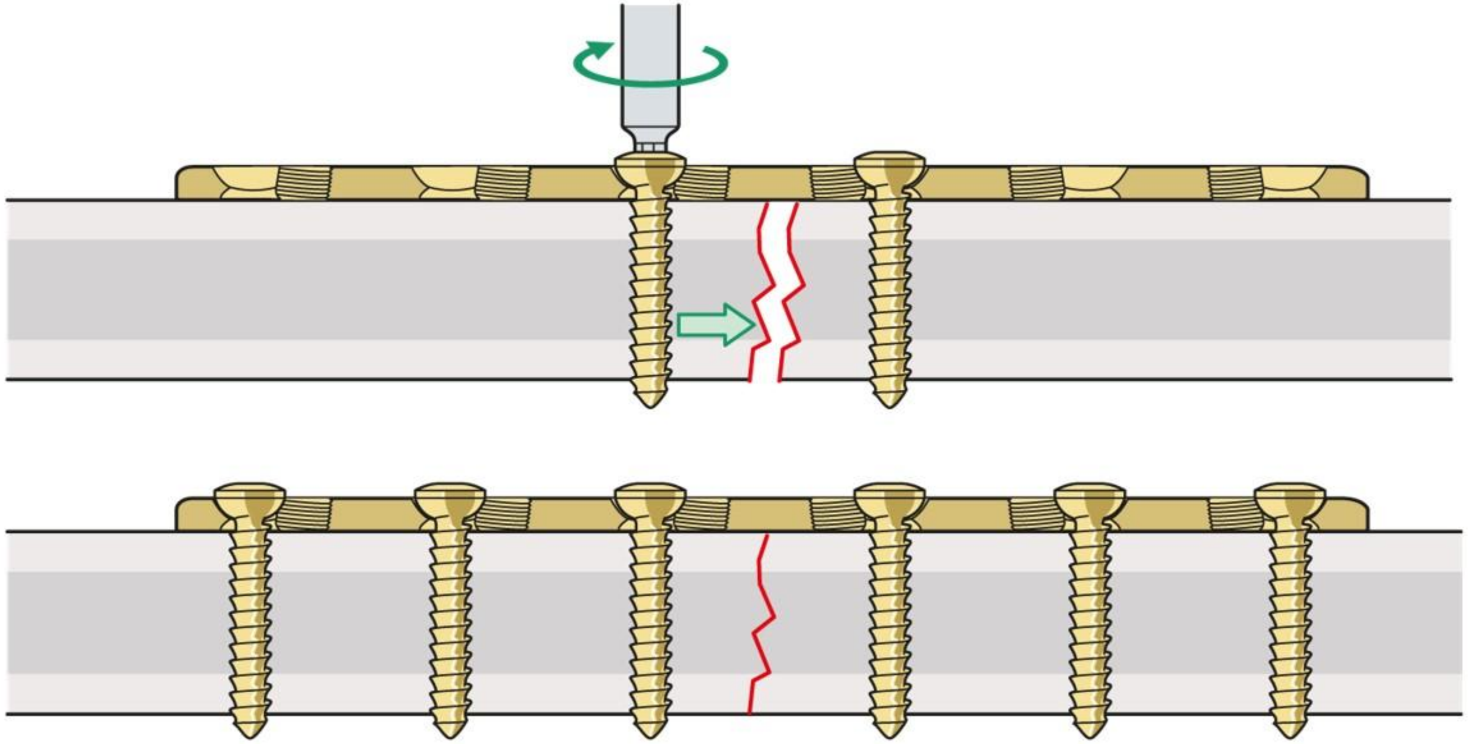
c After that, the first screw is tightened again

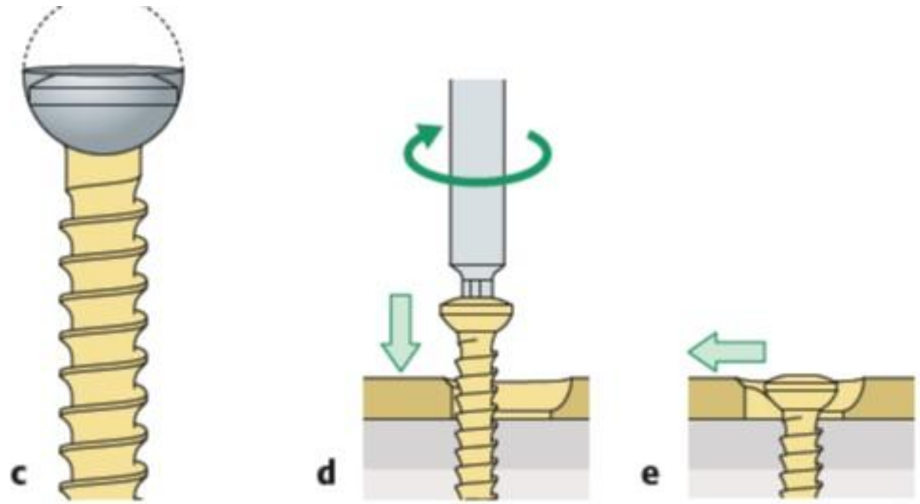
Compression by DCP

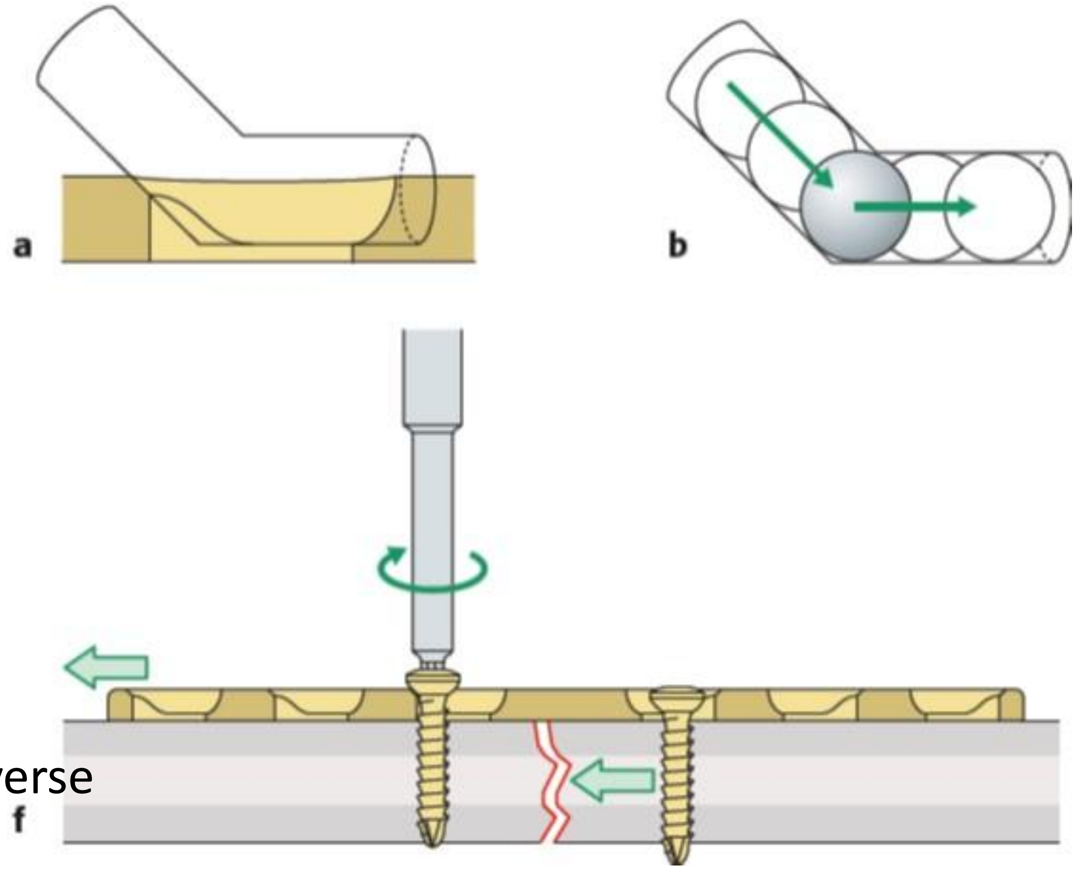
- Eccentrically placed screw – away from the fracture site
- Screw tightening leads to fracture compression

displacement of up to 1.0 mm









The dynamic compression principle.

a The holes of the plate are shaped like an inclined and transverse cylinder.

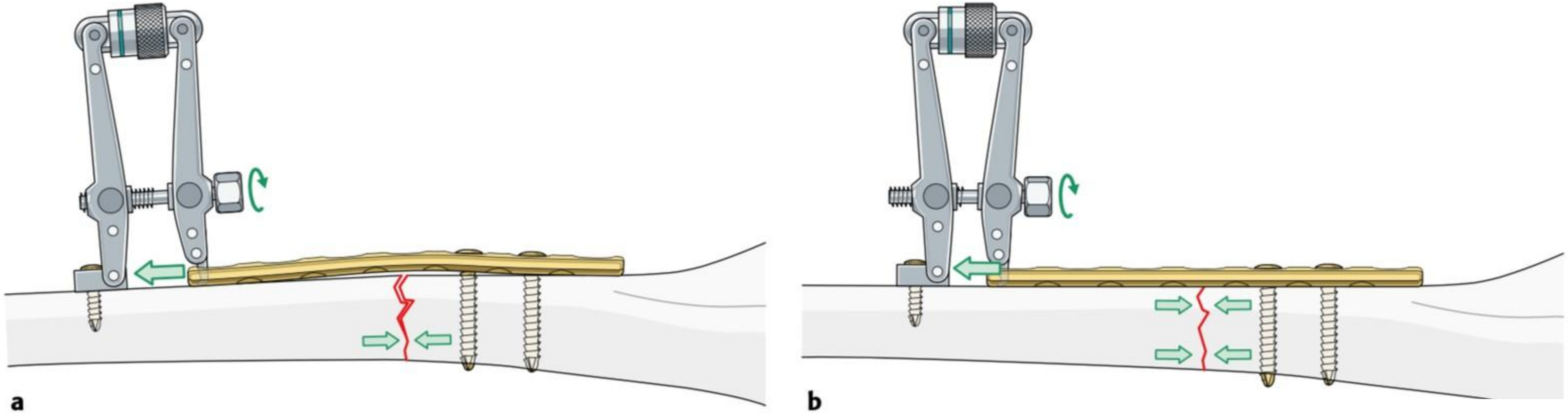
b–c Like a ball, the screw head slides down the inclined cylinder.

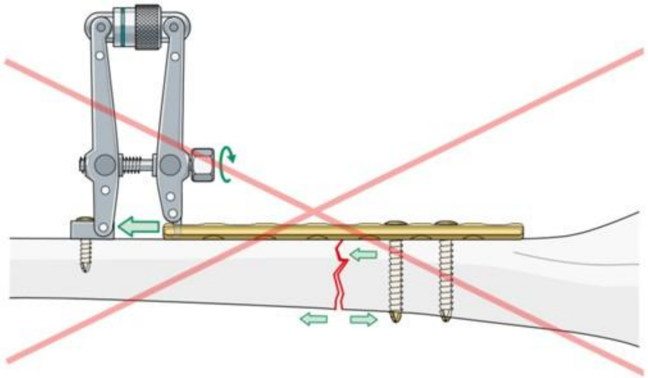
d–e Due to the shape of the plate hole, the plate is being moved horizontally when the screw is driven home.

f As the second screw is tightened, further horizontal sliding of the plate moves the bone toward the bone fragment, thereby achieving compression

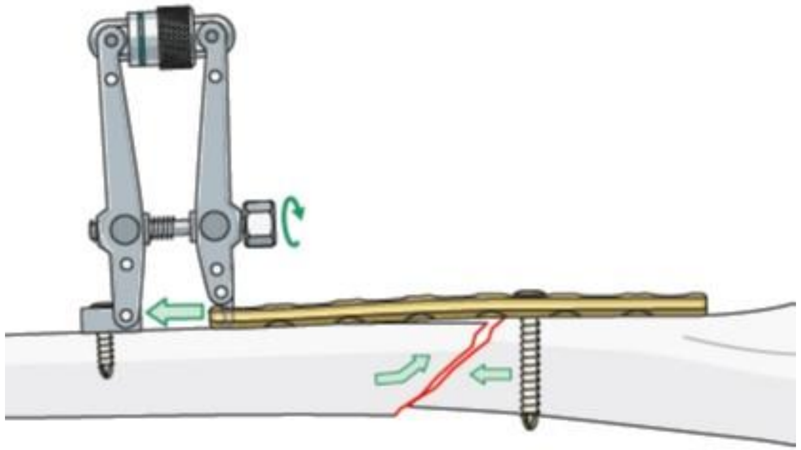
Compression by plate over-bending

Compress by tension device or eccentric screws

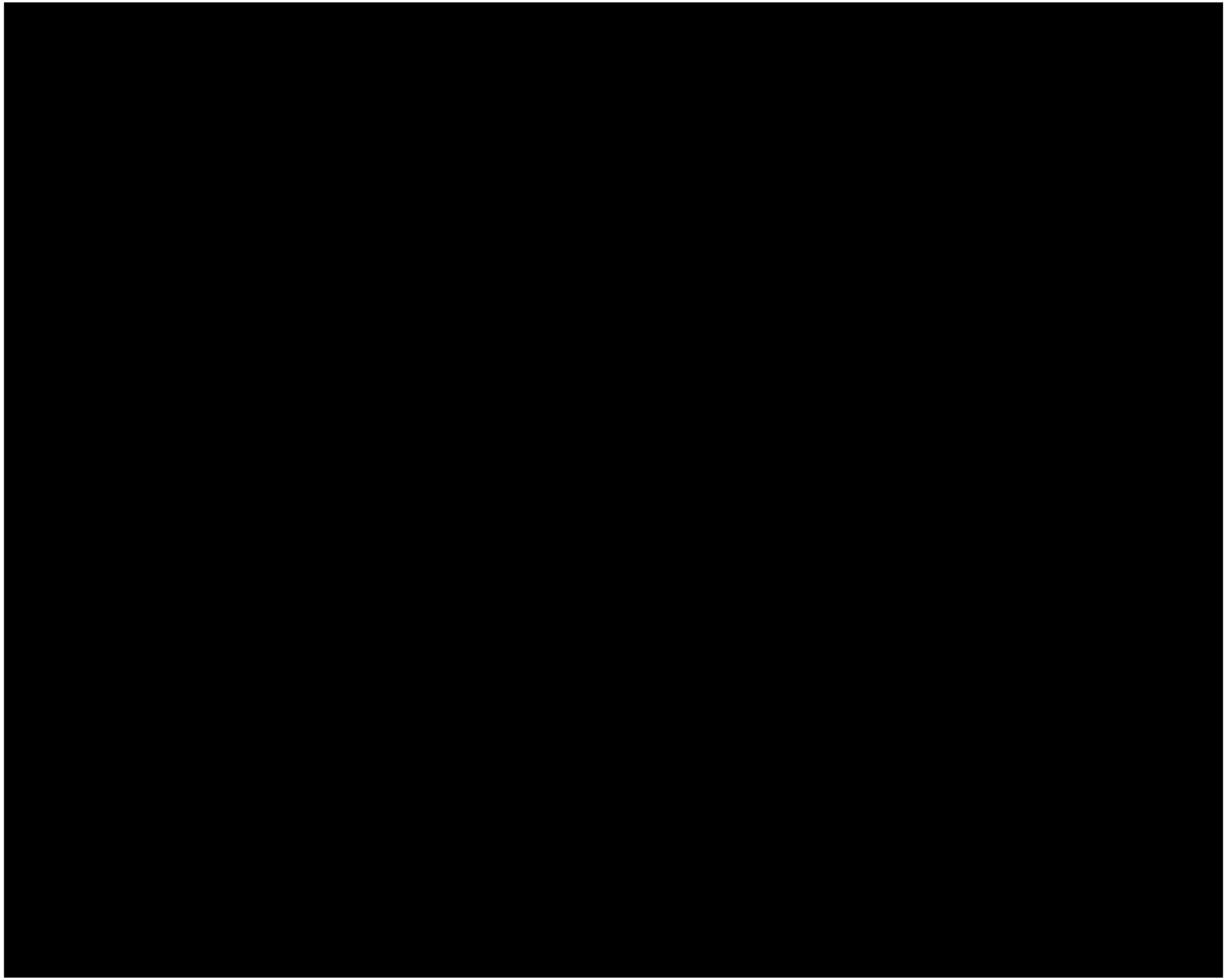




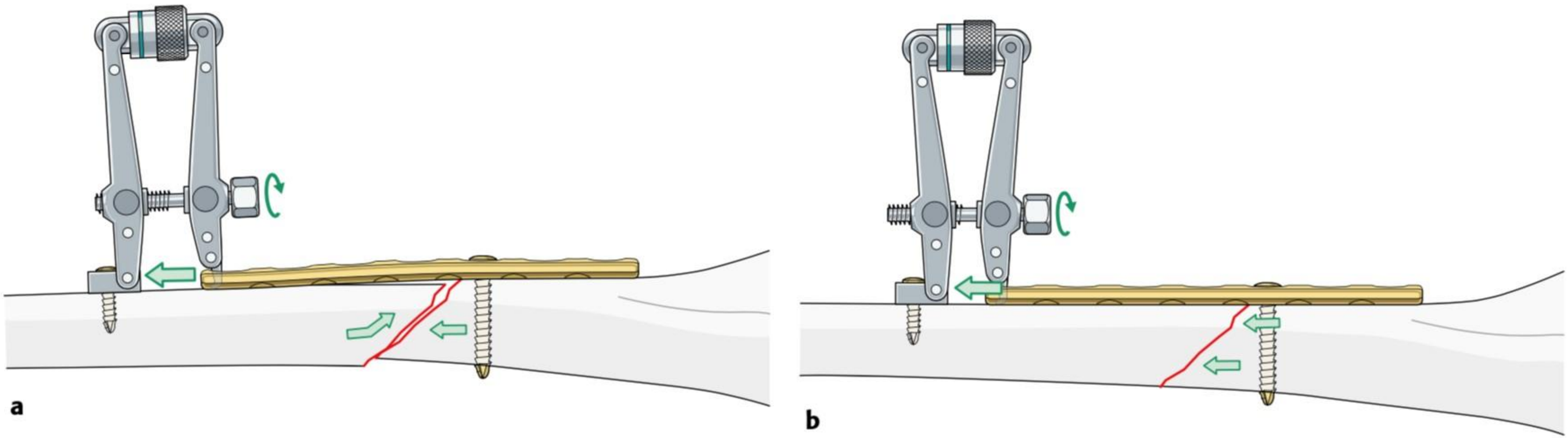
Tension of straight plate on straight bone – opens opposite cortex



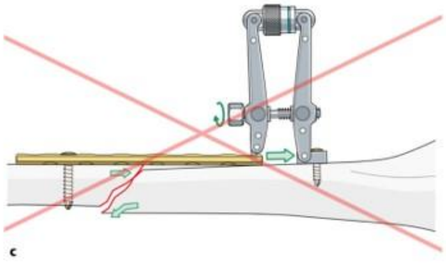
Articulated tension device

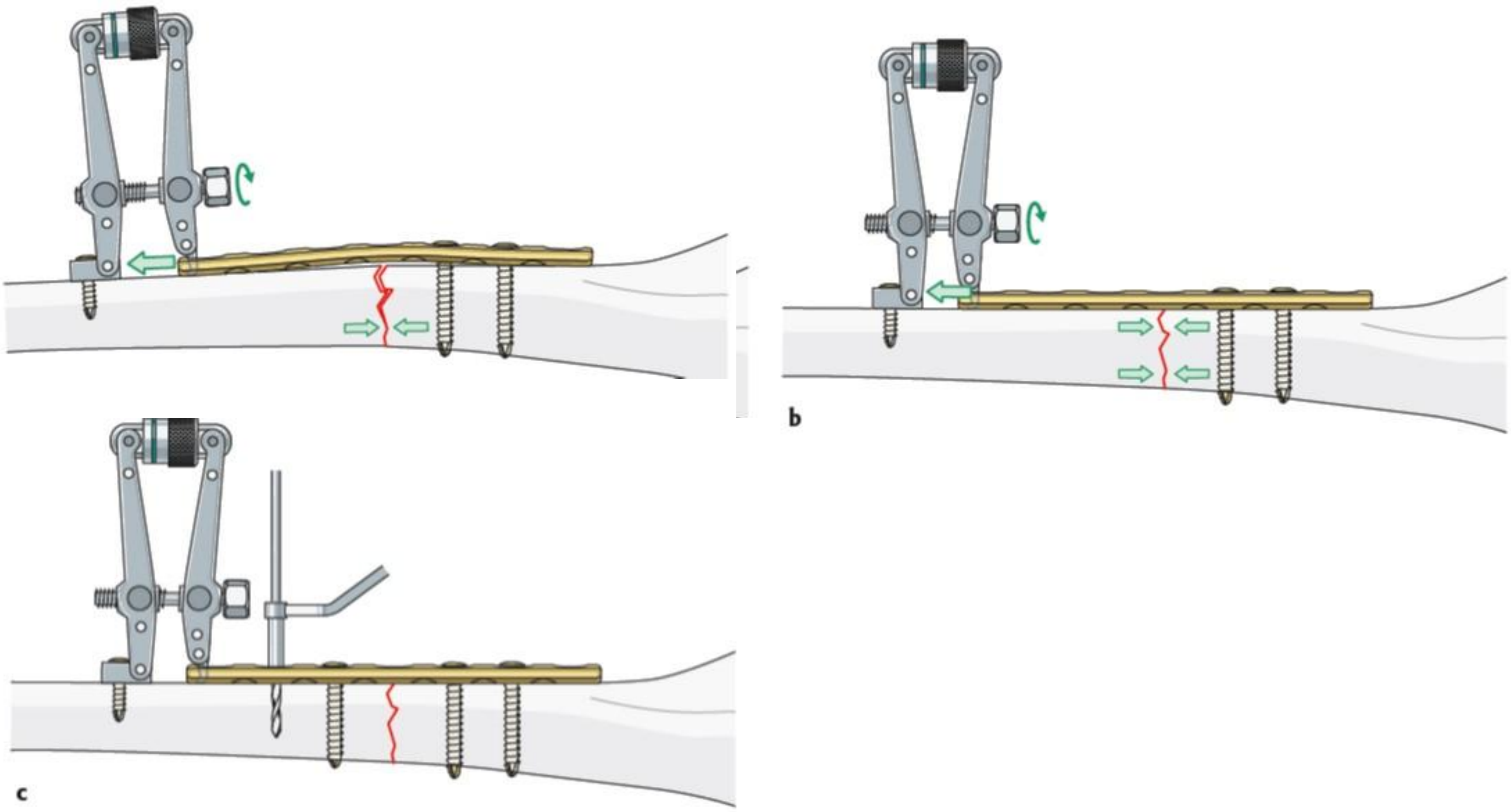


Compression by tension device



Compress into the axilla of the fracture



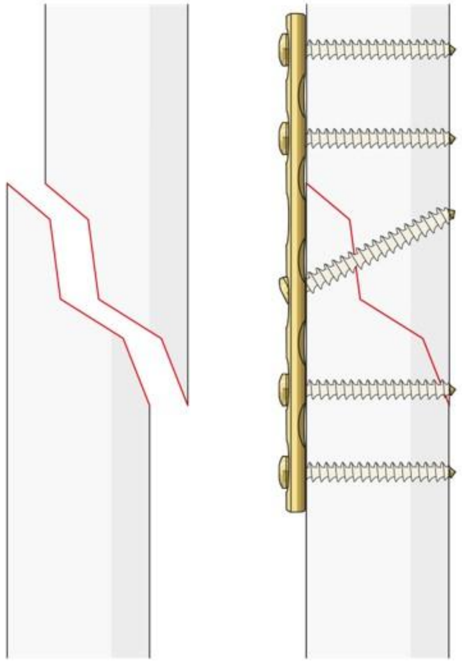


b

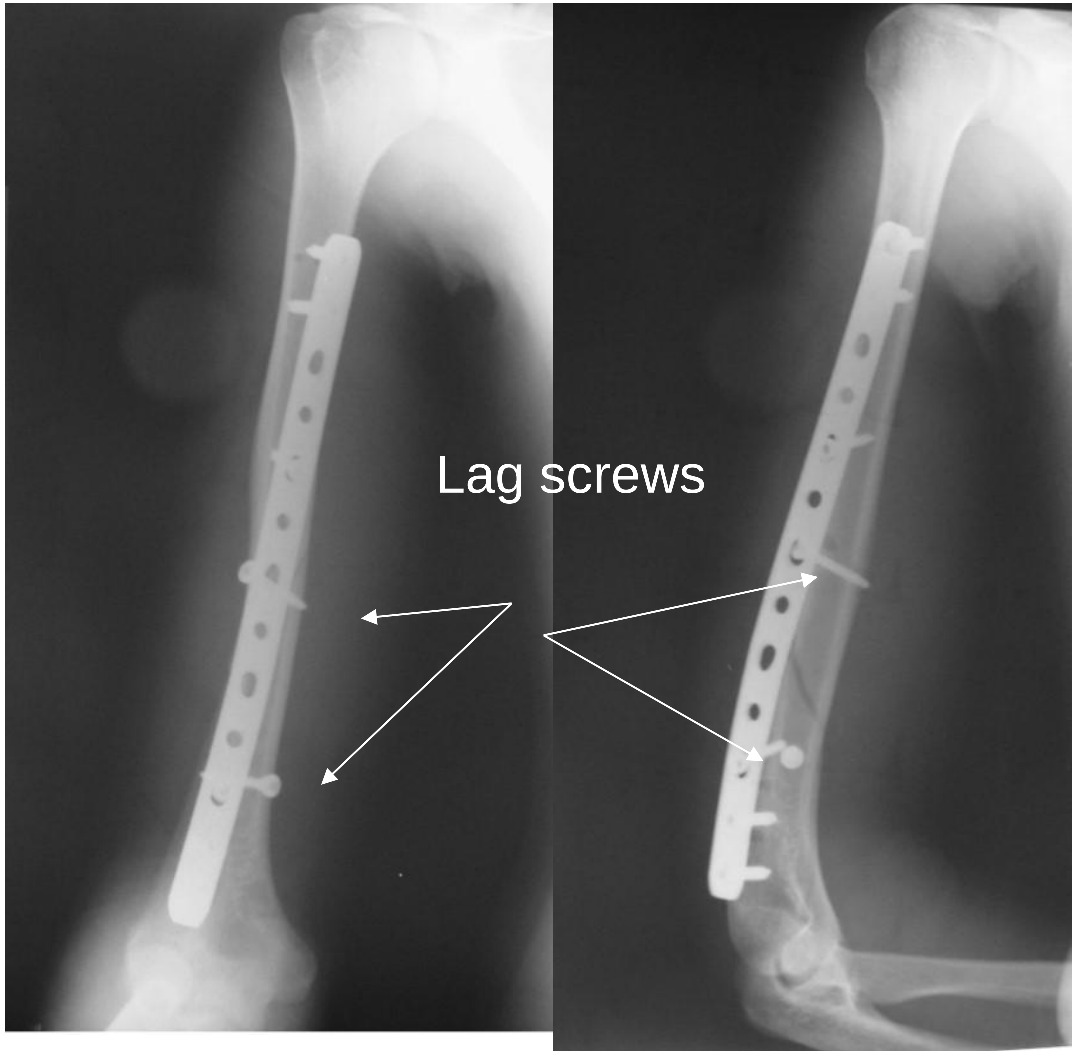
c

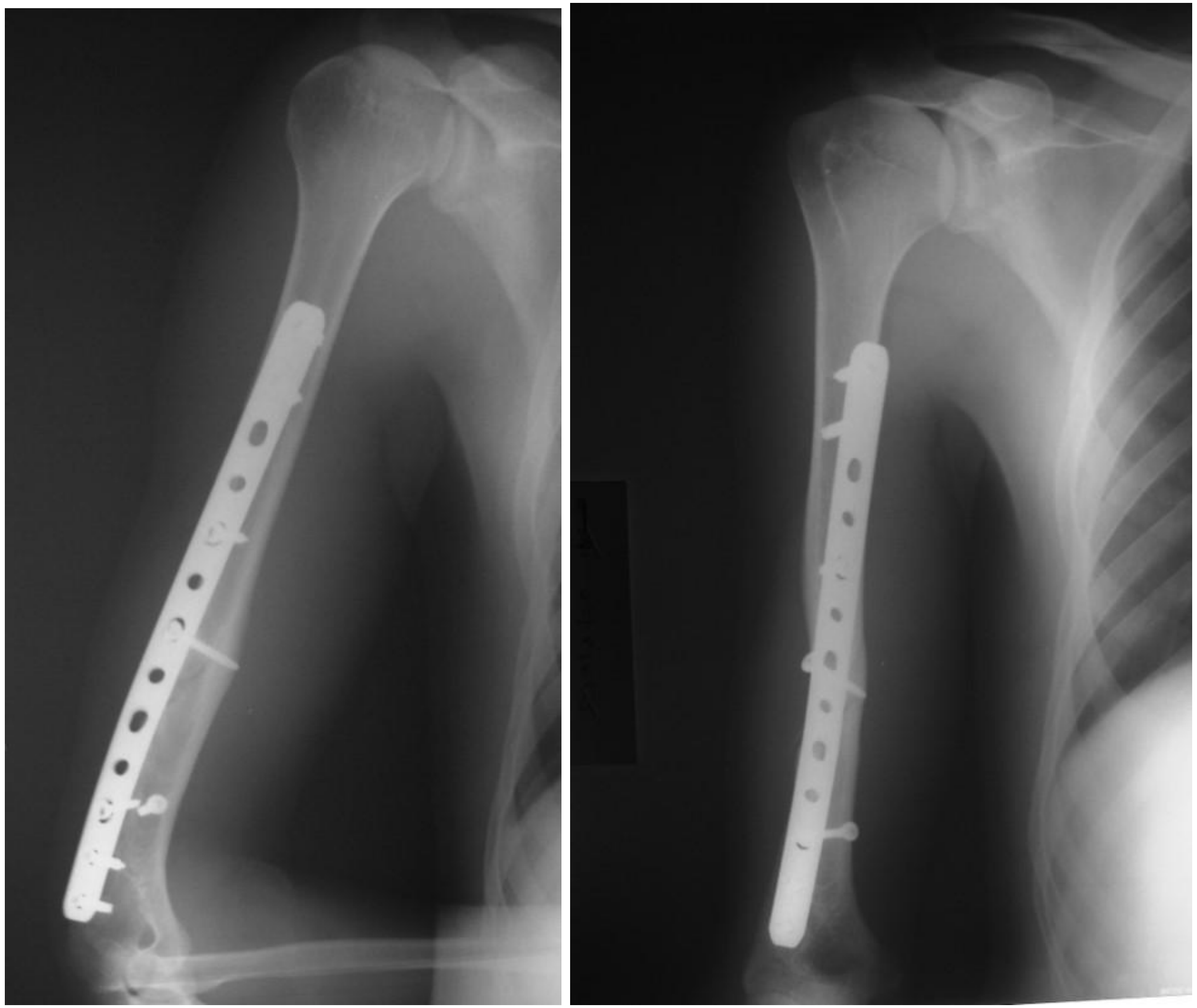
Protection plate: (neutralization)

- Protects interfragmentary lag screw
- Resists torsion, bending, and shear forces
- Absolute stability – direct bone healing



Protection plate





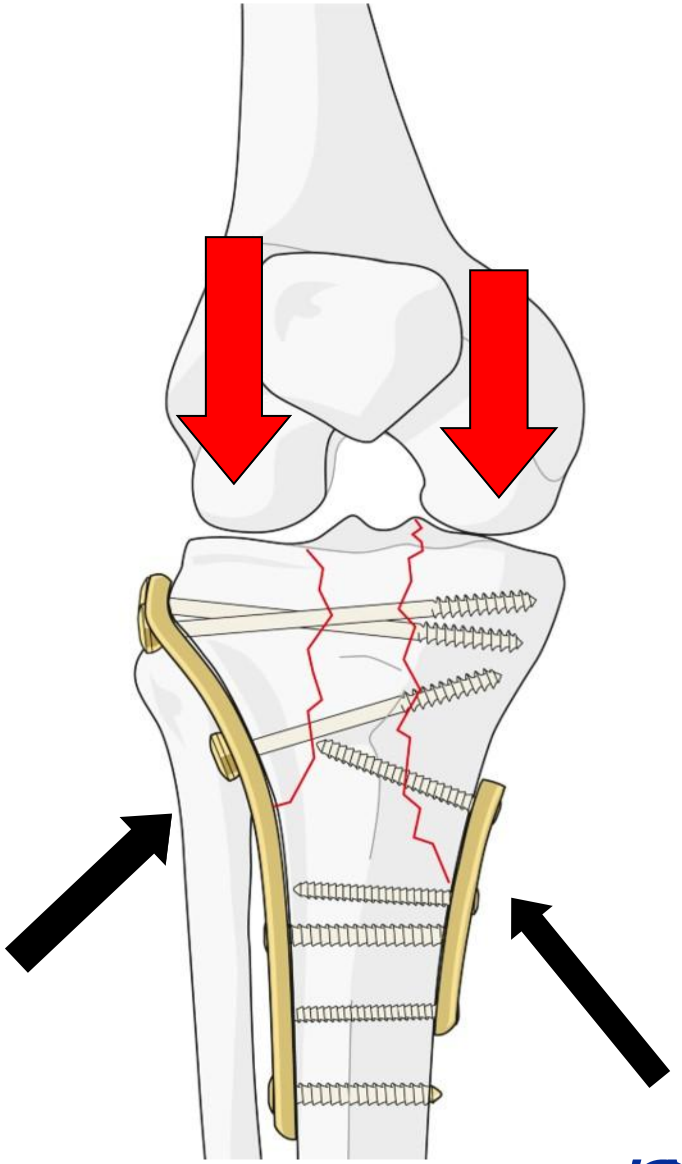
Buttress/antiglide plate

A buttress plate resists axial load by applying force at 90° to the axis of potential deformity.

Buttress plate

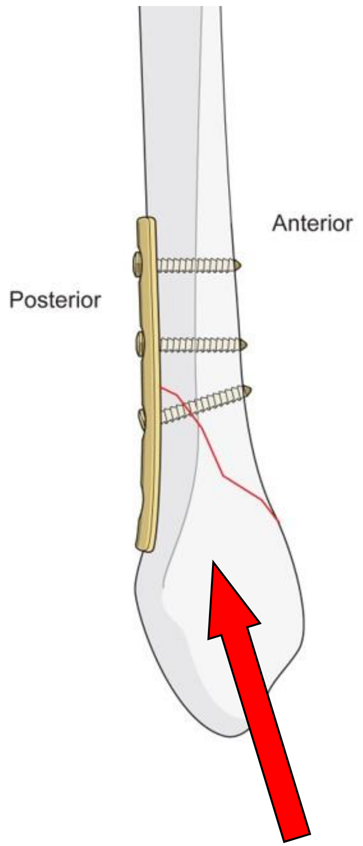
- Resists axial shear load by applying opposir force

- In areas where bone is not supported by the shaft, eg, condyles
  - Distal femur
  - Tibial plateau
  - Ankle



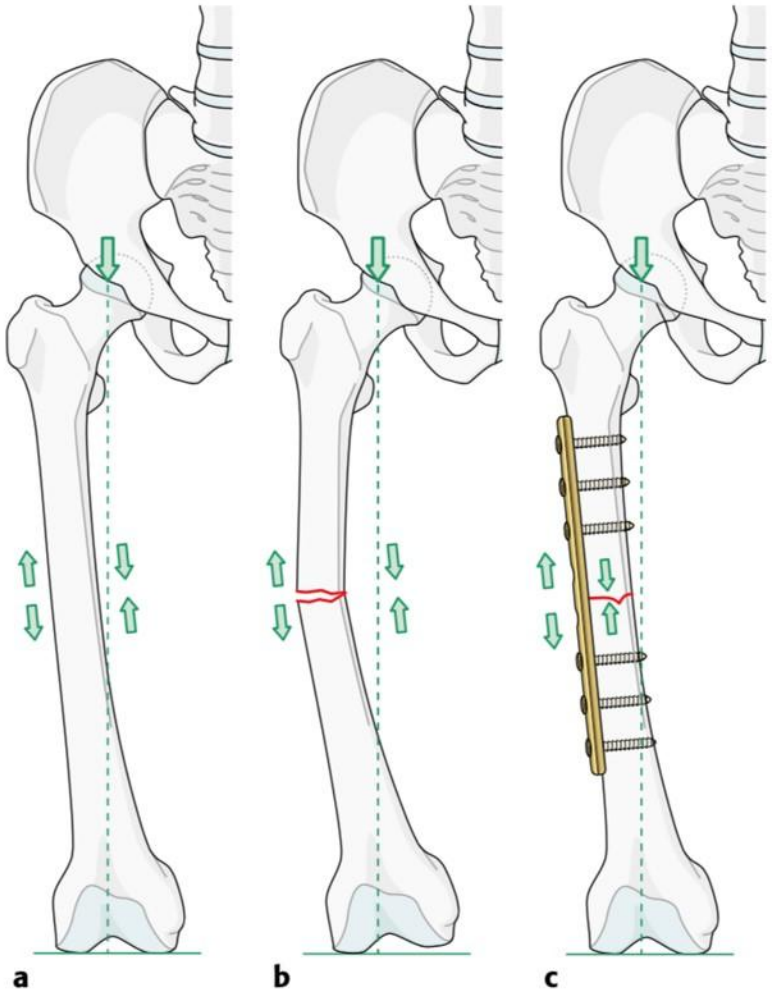
Buttress plate

antiglide plate



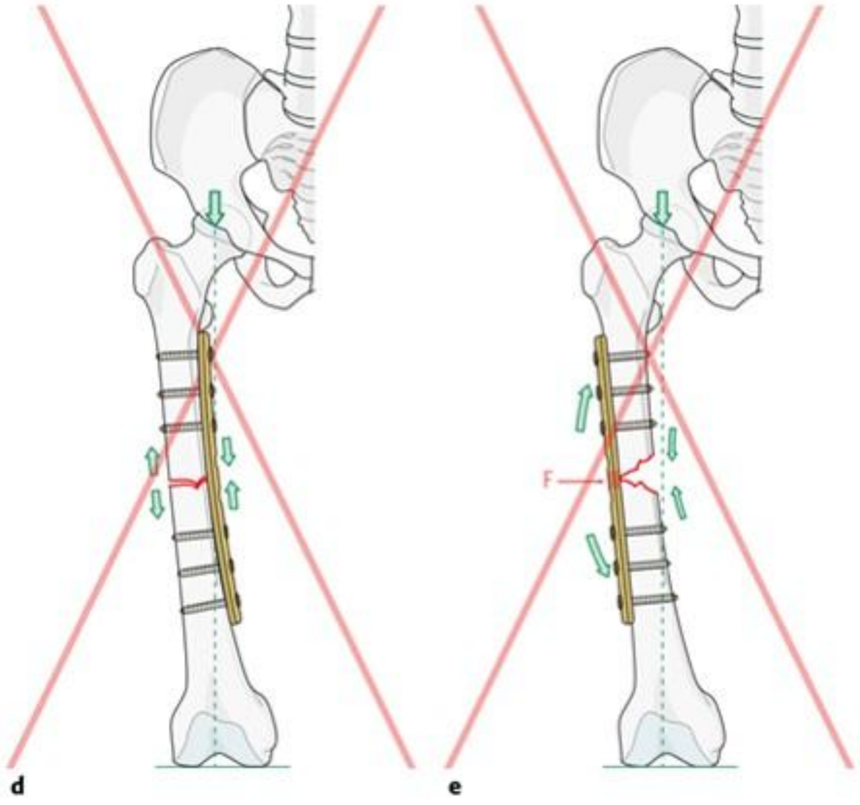
Tension plate: converting tension to compression

- Curved bone: eccentric loading
- Plate on tension (convex) side
- Intact opposite cortex



The fractured bone must be eccentrically loaded, eg, femur

- The plate must be placed on the tension (convex) surface
- The plate must be able to withstand the tensile forces
- The opposite cortex must be able to withstand compressive force

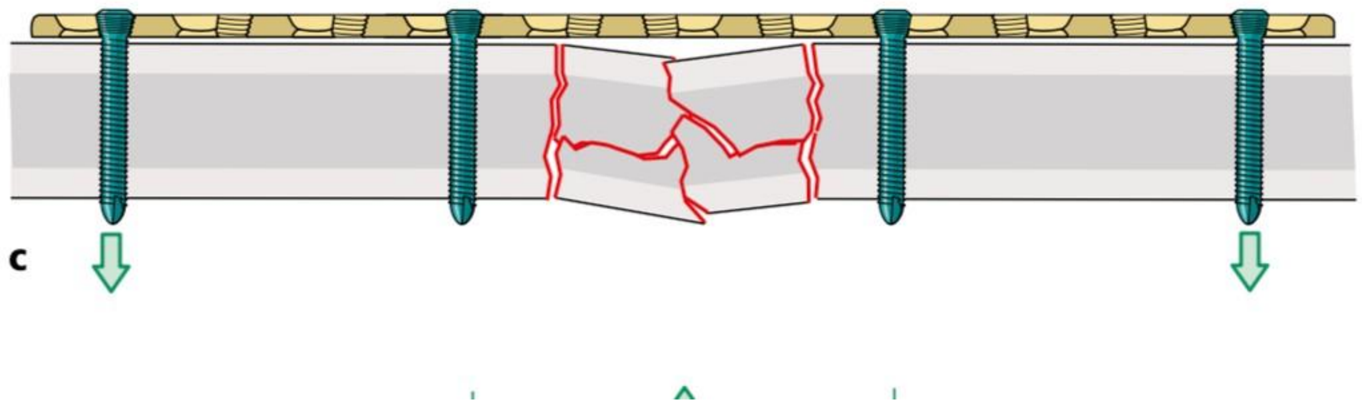


The function of a tension band is to convert tensile force into compressive force. After fracture reduction, the opposite cortex must provide a bony buttress to prevent cyclic bending and failure of fi xation.

AO

Bridging plate

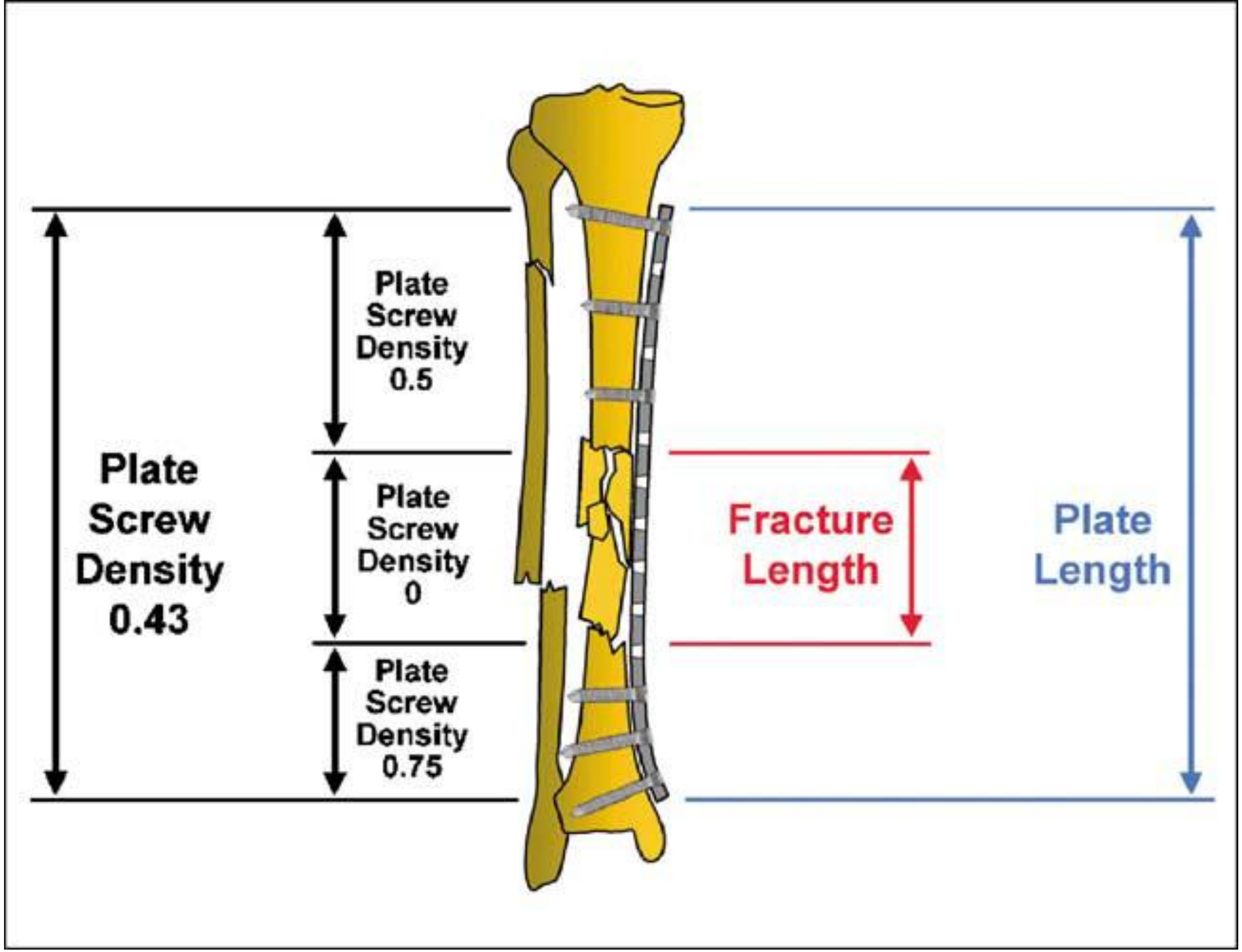
- Multifragmentary fractures
- Bridge the fracture site: restore length, rotation, and angulation
- Relative stability – healing by callus



Length of the LCP

plate span ratio

plate screw density



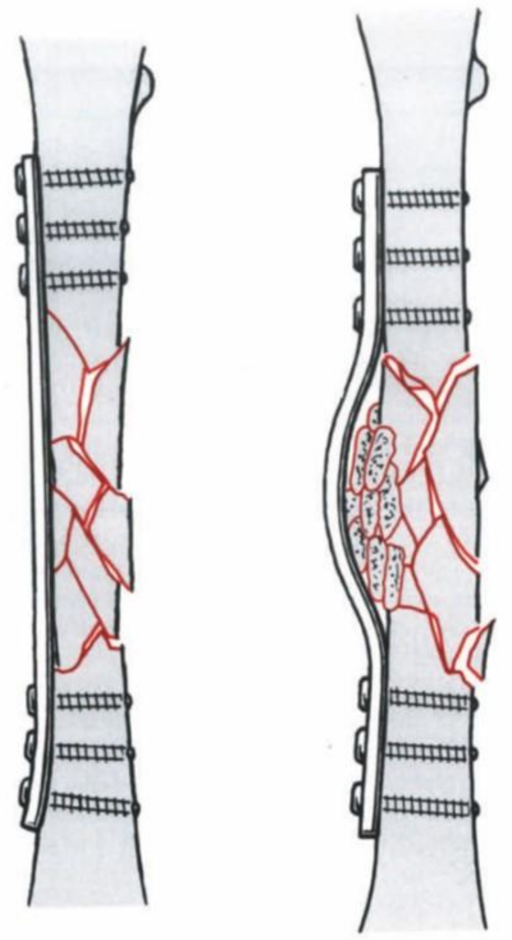
Gautier et al.: Guidelines for the clinical application of the LPC

	Simple fracture	Comminuted fracture
Biomechanical concept	Compression technique Rarely bridge plating	Bridge plating technique
Reduction	Mainly direct	Indirect
Implant insertion	Partially open	Minimally invasive
Plate **Shaping**	Conform to bone surface	Not needed
Length (plate span ratio)	$> 8 - 10$	$> 2 - 3$
Screws	Standard and locked	Locked
Type of screws	Mainly bicortical	*Diaphysis:* selfdrilling monocortical *Epi- and metaphysis:* selftapping bicortical
Plate screw density	$< 0.4 - 0.3$	$\leq 0.5 - 0.4$
Number of screws per main fragment	≥ 2	≥ 2
Number of cortices per main fragment	≥ 3	≥ 4
Screw position	Short middle segment without screws	Long middle segment without screws
Empty plate holes over fracture	$0 - 3$	≥ 3

Gautier et al.: Guidelines for the clinical application of the LPC

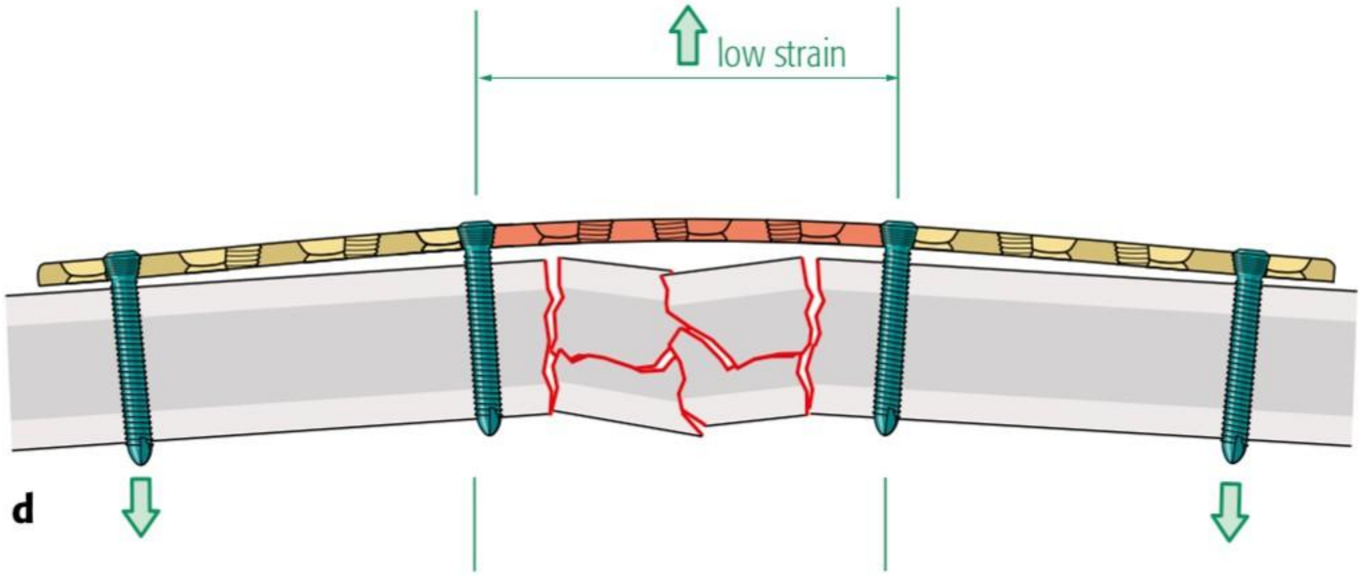
Screw to plate hole ratios of
less than 0.5 create a long lever arm and decrease the bending
loads on the distal screws

A plate length of more than three
times the fracture length in multifragmentary fractures, and
more than eight to ten times the fracture length in simple
fractures has been taught



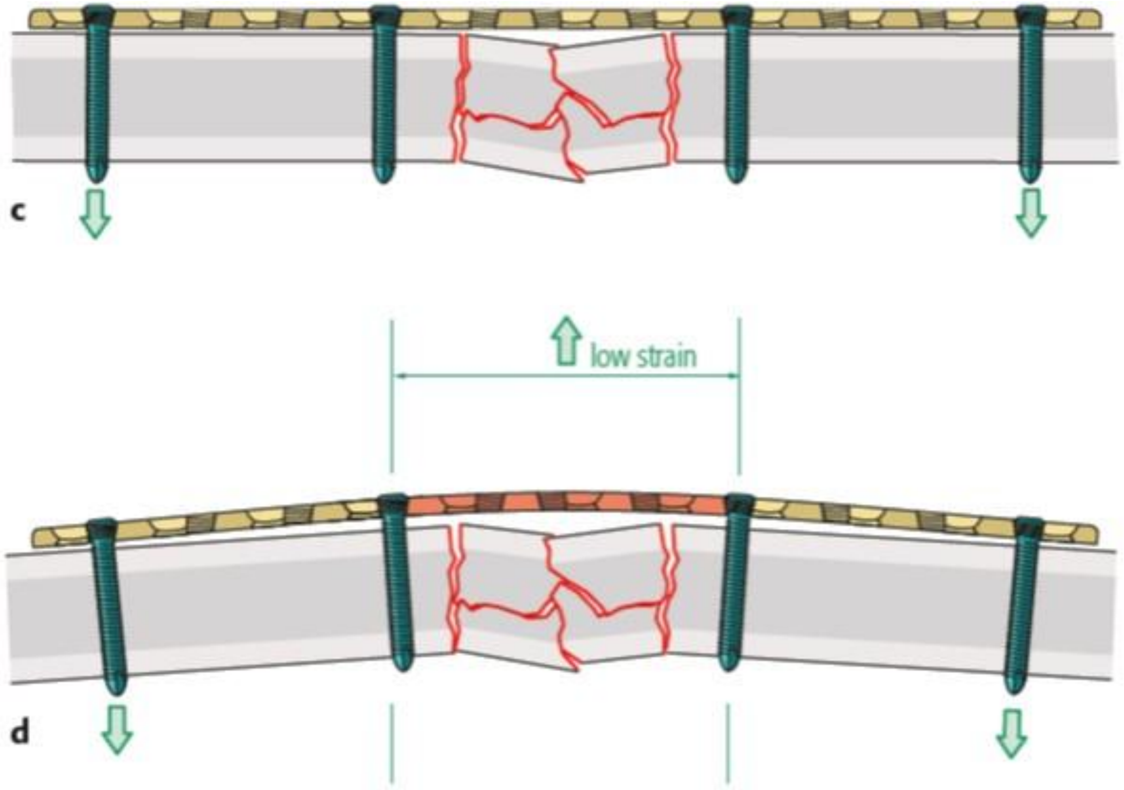
Bridging plate: tips

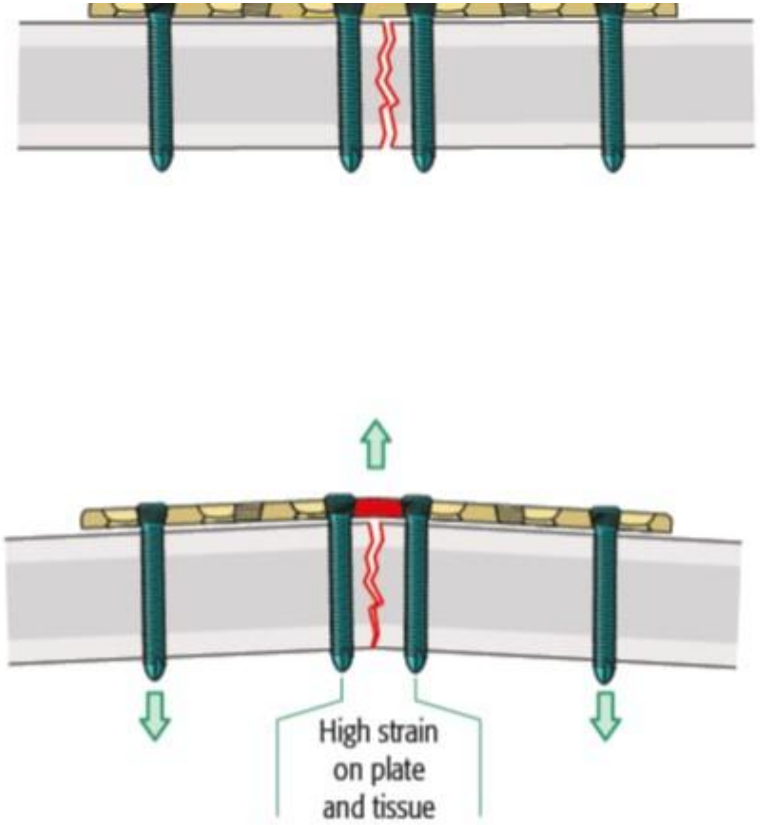
- Long plates: three times the length of the fracture
  - Increase level arm
  - Decrease load on distal screws
- No screws in fracture area



two or three screw holes should be left open over the fracture

to decrease stress concentration



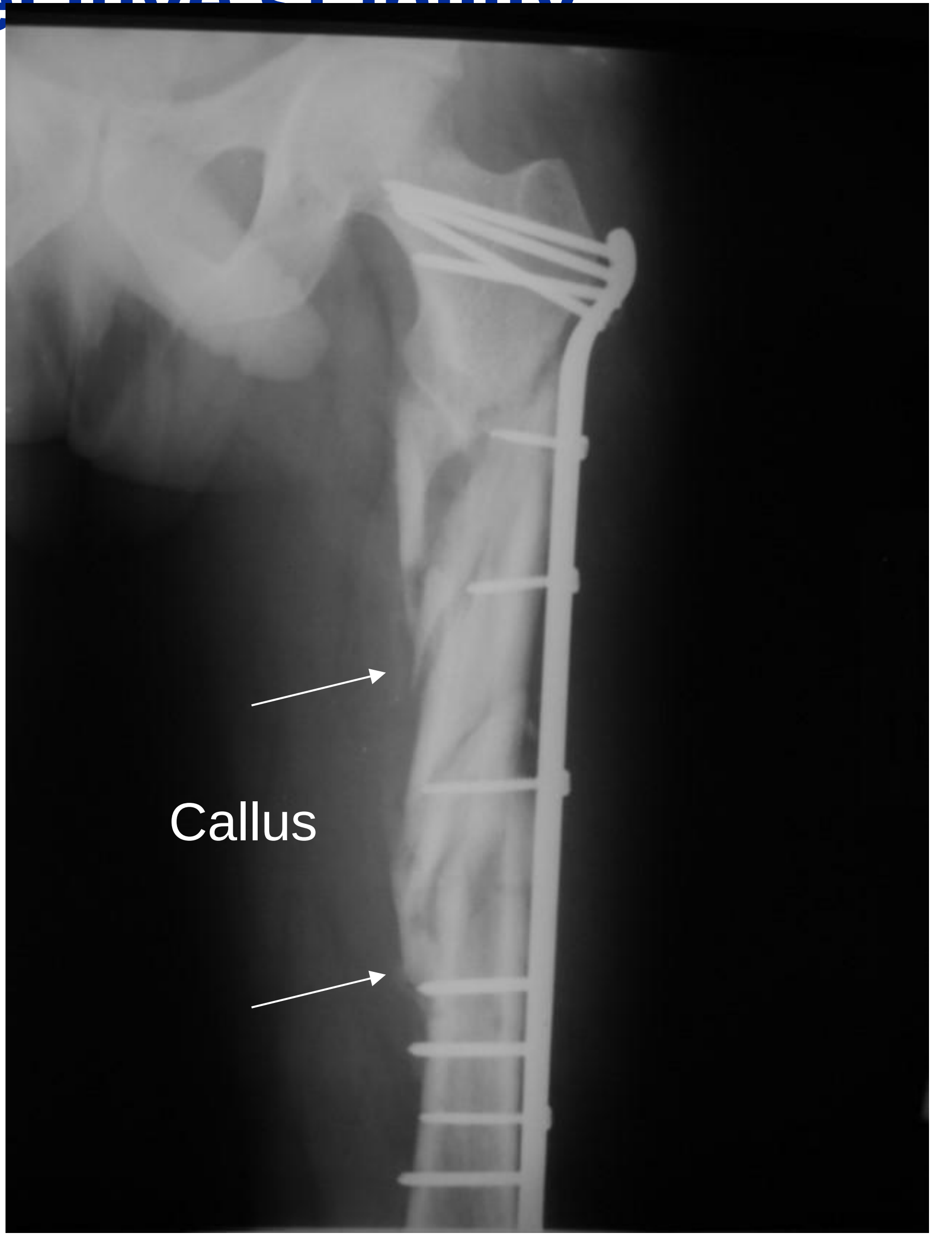


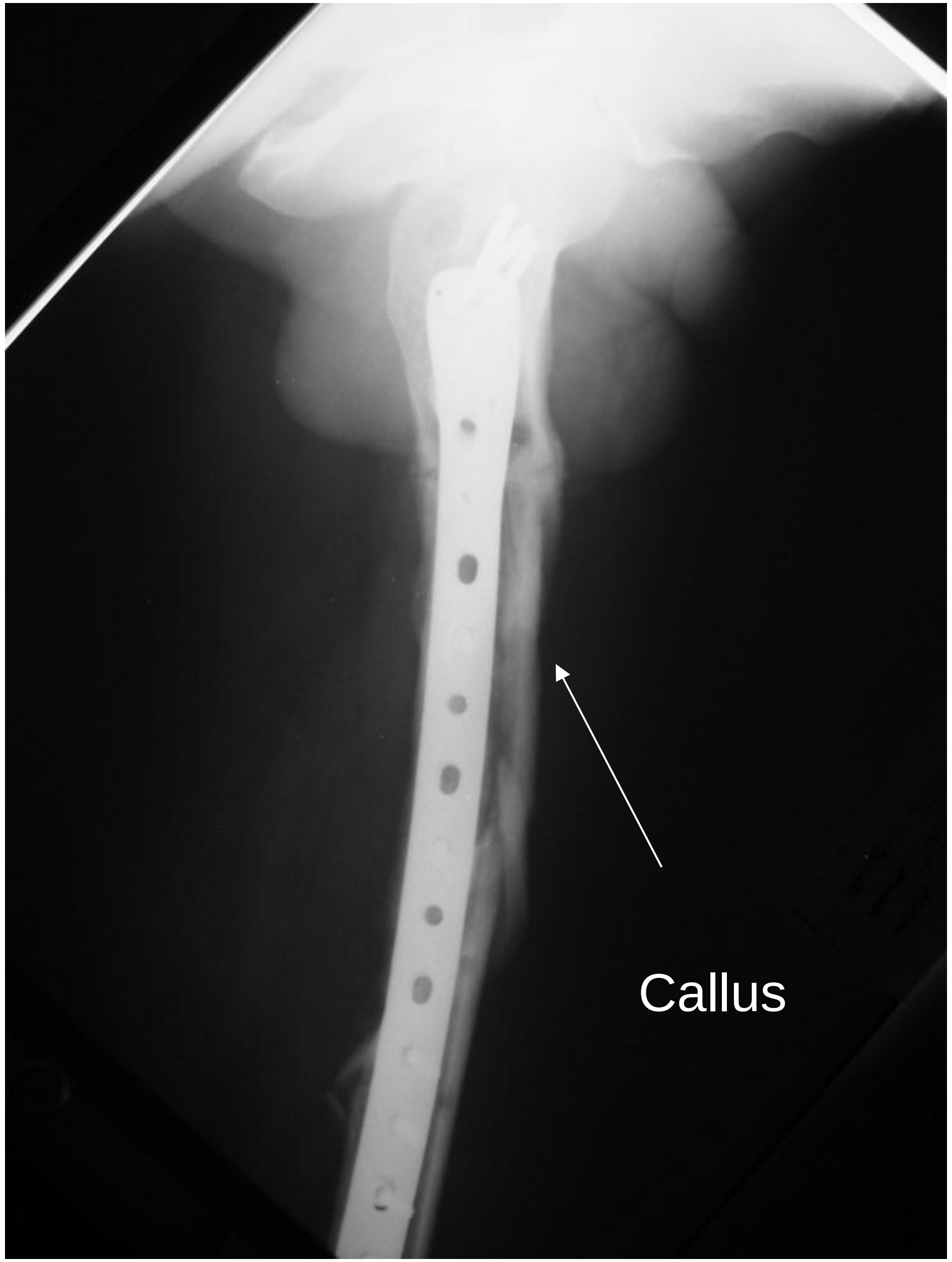
less invasive stabilization system (LISS)

internal fixators and can

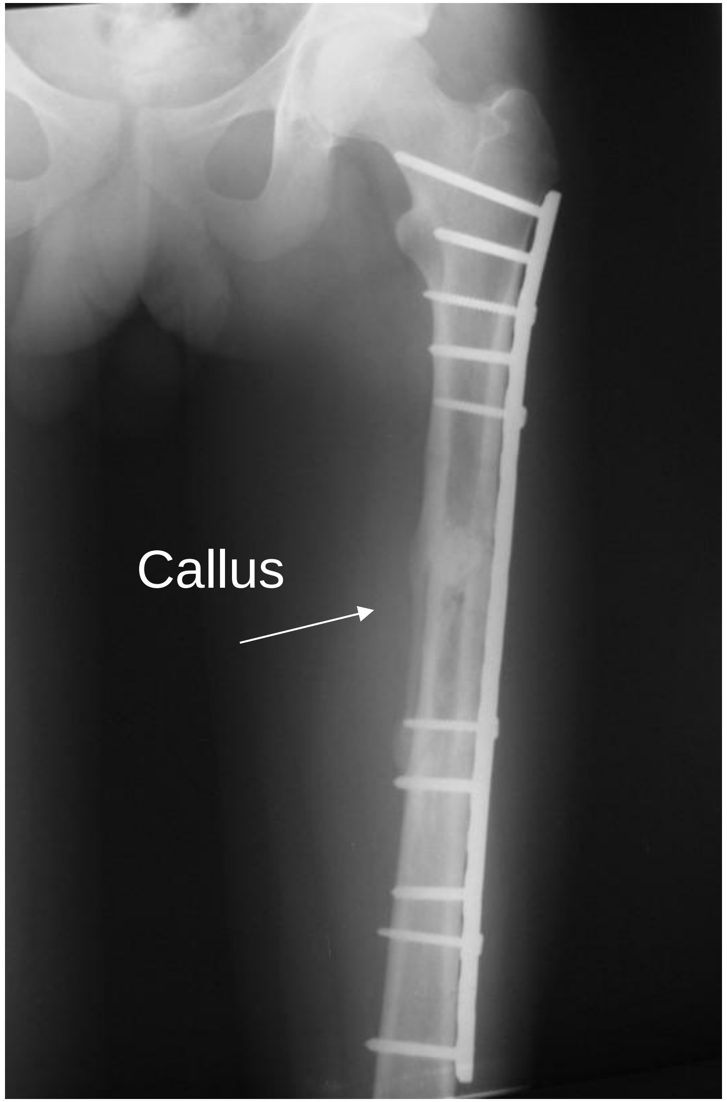
only provide a bridging function.

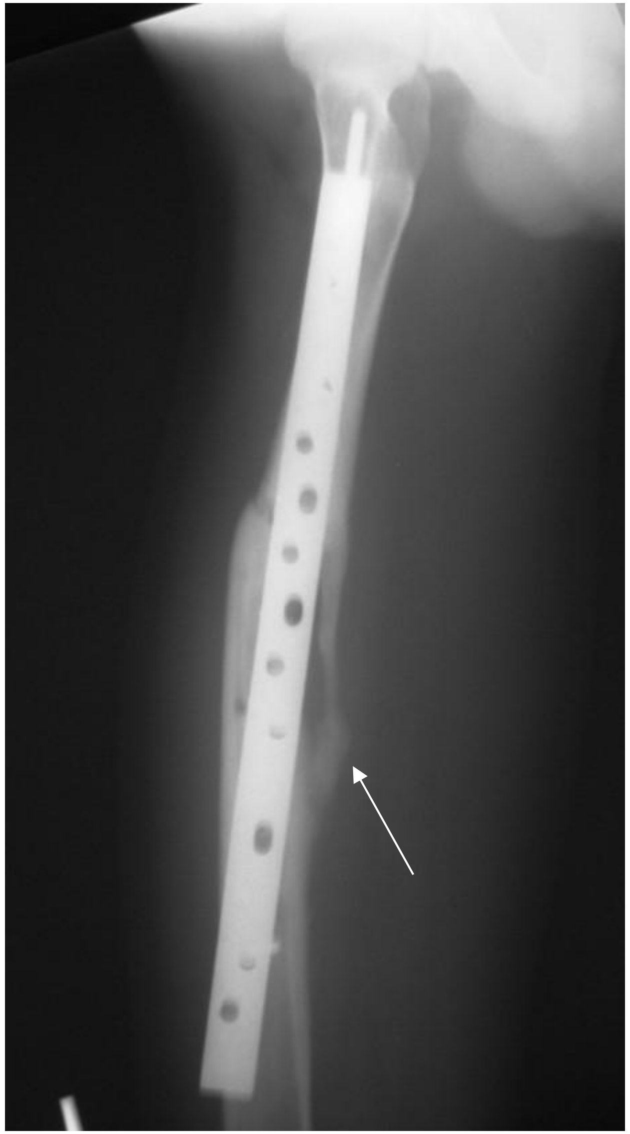
Relative stability





Relative stability





Locking plates: indications

- Osteoporotic bone
  - Elderly patients
  - Nonunions
- Short segment of bone (not enough screws) eg, condyles
- MIPO

Locking plates: tips

- Locking screws: cannot be used for reduction
- “Reduce before locking”
- Locking screws: not lag screws
  - But can maintain compression produced by other means
- Osteoporotic bone:
  - Relative stability instead of absolute stability
  - No lag screws

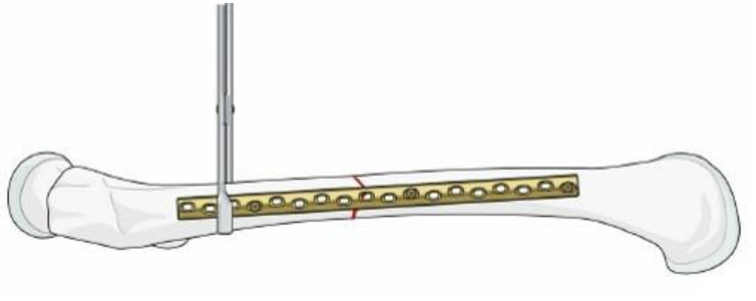
angular-stable screws, the fixation

does not require the plate to be compressed to the bone for stability. The combi-hole design also allows standard screws to be inserted into neutral or load holes and this allows the LCP to be used to perform any of the six biomechanical functions of a standard plate.

Once a locking head screw has been inserted into a fracture fragment, no (additional) conventional screws should be inserted into this side of the fi xation—only additional locking head screws may be used. “Reduce and lag fi rst, lock second

Plates as a reduction tool

- Helps in fracture reduction
- Depends on fixing the plate on one side
  - Then tightening the screws to push the fragment (buttress plates)
  - Or using reduction tools on the opposite side (shaft plates)
- Works with nonlocking screws only



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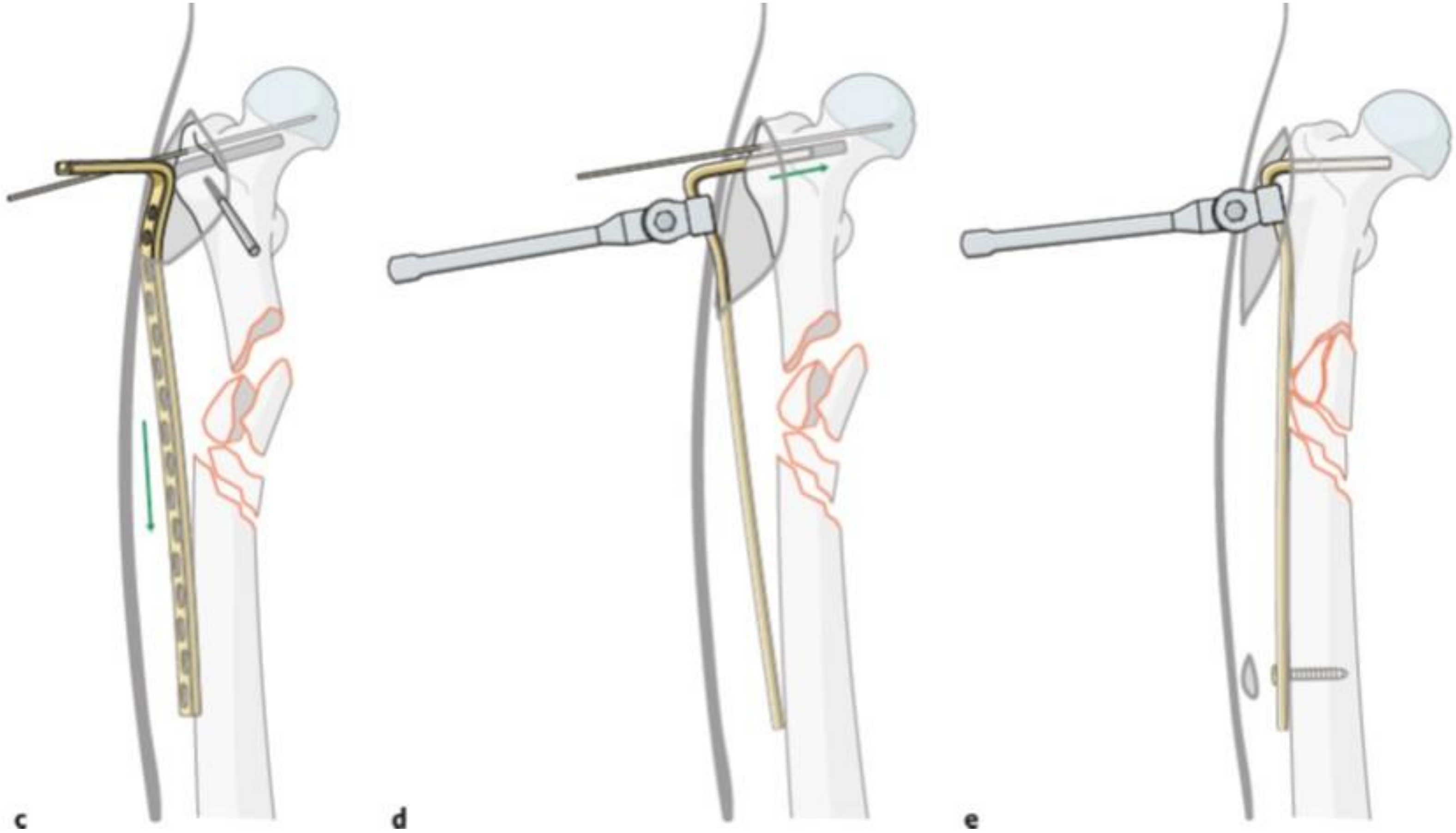
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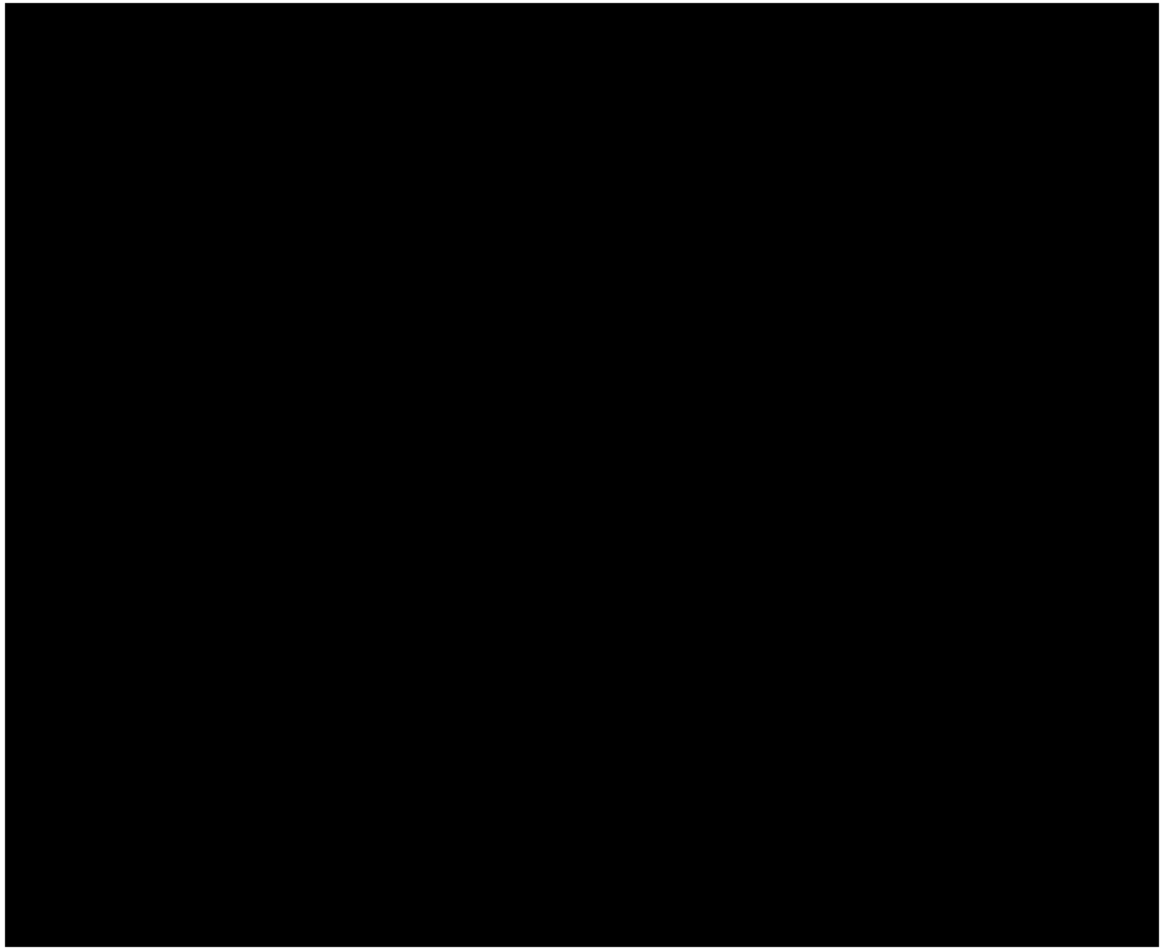

Plate function	Biomechanics	Example of application
Compression	The plate produces compression at the fracture site to provide absolute stability.	Simple transverse humeral fracture
Protection	The plate neutralizes bending and rotational forces to protect a lag screw fixation.	Simple oblique radial fracture
Buttress	The plate resists axial load by applying force at 90° to the axis of potential deformity.	Lateral tibial plateau fracture
Tension band	The plate is attached to the tension side of a fracture and converts the tensile force into a compressive force at the cortex opposite the implant.	Olecranon fracture
Bridging	The plate provides relative stability by fixation to the two main fragments, achieving correct length, alignment, and rotation. The fracture site is left undisturbed.	Multifragmentary ulnar fracture
Reduction	The plate assists in the direct reduction and overall position of fracture fragments that is either temporary or definitive. The plates do not harm fracture biology but are needed to provide accurate positioning of fracture fragments as definitive fixation can be achieved.	Multifragmentary proximal tibial fracture

Table 3.2.2-1 The six functions of a nonlocking plate.

Take-home messages

- Plates have different functions in fracture fixation depending on their application method
- They can produce absolute or relative stability
- Locking plates have specific indications
- Plates can be used as a reduction tool