INTERNAL FIXATION

DEPT OF OMFS
SVDC

Contents

INTRODUCTION

DEFINITIONS

RIF can be defined as any form of fixation applied directly to the bones which is strong enough to permit active use of the skeletal structures during the healing phase.

RIF can also be defined as a technique that does not allow micro motion of the fracture segments during normal functional movements.

HISTORY

- **Sushruta** – 11th century AD – Manual manipulation, heat application and complicated bandaging.
- **Alexis Pujol** – 1775 – Published account of internal fixation.
- **Jean Baptiste Baudens** – 1840 – Used silver thread to approximate mandibular fractures.
- **Hansmann** – 1886 – Developed retrievable bone plate.
- **key** - 1932 - 1st employed positive pressure (compression) to bone segments for tuberculous Knee arthrodesis.
- **Danis** – 1947 – Developed true compression plate.
- **Maurice** –1958 - Adapted the principle of AO / ASIF

- **Michelet and Champy** – Advanced the evolution of plate fixation
- **Luhr** – 1977 – adapted the principle of dynamic compression to mandibular fracture.
- **ECDP** – designed for the situation in which a tension band is not possible.
- **Reconstruction plates** were introduced
- **Raveh** -1993 – introduced THORP system
- **Getter et al –** 1972 - introduced Bioresorbable plates

Bone

Chemical composition:

Inorganic 65%

Hydroxyapatite

Mg,Ca,Cl,Fe, Carbonate

Organic:

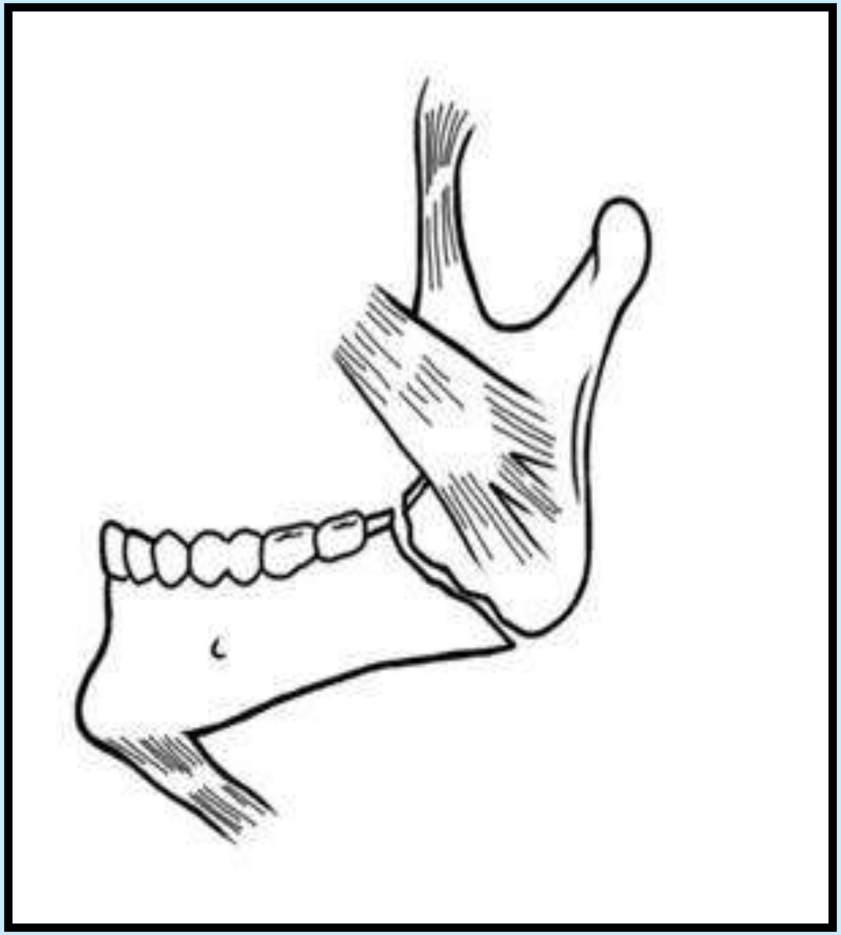
90% collagen type I

10% - Non collagen type proteins

23% osteonectin, 15% osteocalcin, 9%sialoproteins,9% phosphoproteins, 5% alpha 2 HS glycoproteins, 3 % albumin

The fracture mechanism

- Mandible can be considered as tubular bone
- Major muscle forces act on angle and ascending ramus
- Reactive forces created on the occlusal plane
- Suprahyoid muscle tend to push the mandible caudally
- Tensile force is created on the alveolar portion.



- Also loading on occlusal plane is quite high:

  Incisor area 200 – 300 N, Premolar region 300 – 500 N,

  Molar 500 – 700 N

- Fracture is result of mechanical overload
  - Torquing force – spiral #
  - Avulsive force – transverse #
  - Bending force – oblique #
- Degree of fragmentation depends on the energy stored prior to the process of fracture.

BONE HEALING

Primary bone healing :

- CONTACT HEALING
- GAP HEALING

Secondary bone healing

Primary bone healing

CONTACT HEALING

•Direct apposition of fracture segments

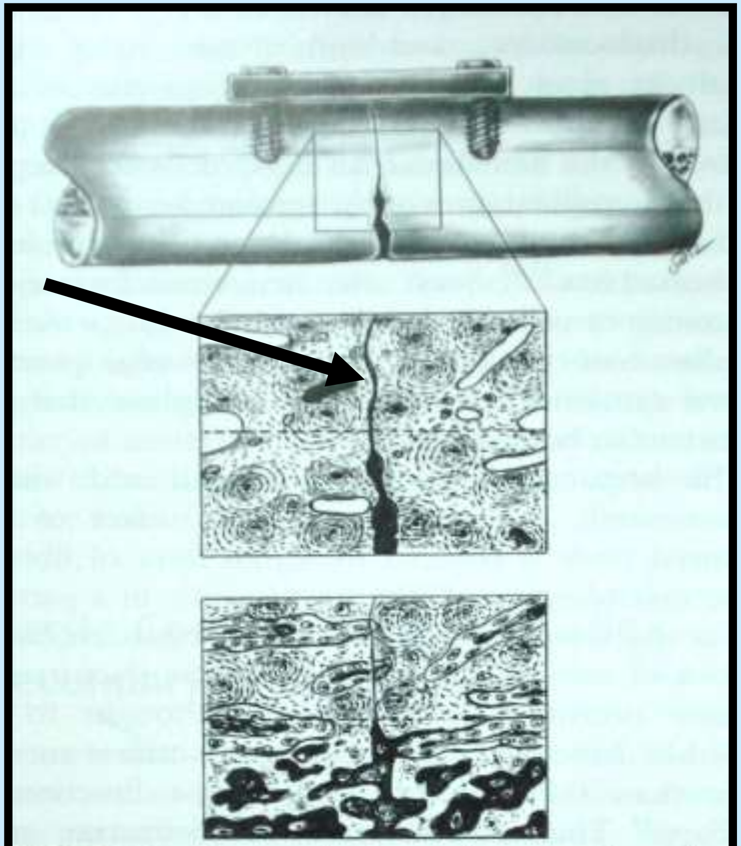
•Widening of the haversian canal by osteoclasts

•Migration of haversian canal towards each other

•Ingrowth of new capillaires & migration of osteoblasts

•Cortical bridging by 8wks

•Healing by 16 wks



URE 39-4 Contact healing and gap healing. The

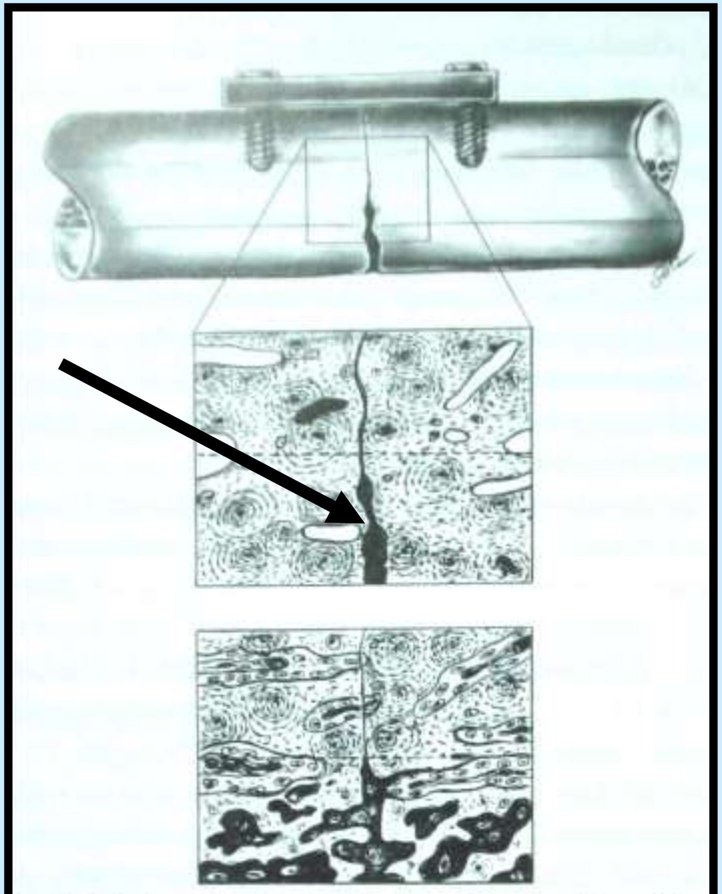
GAP HEALING

•Adequate stability of # fragments required

•Gap as wide as 100 μm heals by primary intention

•Bone is deposited first parallel to fracture & perpendicular to long axis of bone

•Later after remodelling, bone orients along long axis of bone



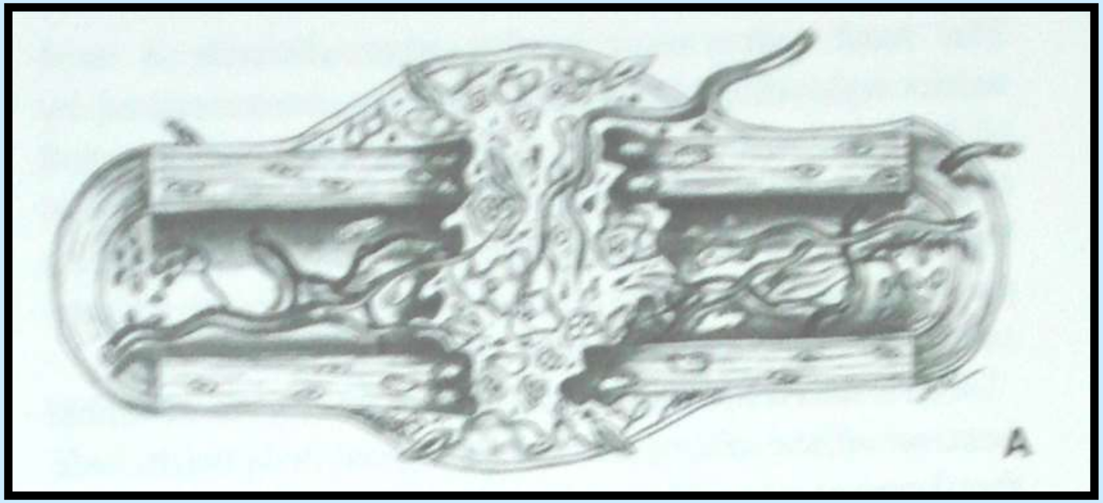
URE 39-4 Contact healing and gap healing. The

CLASSIC CONCEPT (SECONDARY BONE HEALING)

STAGES

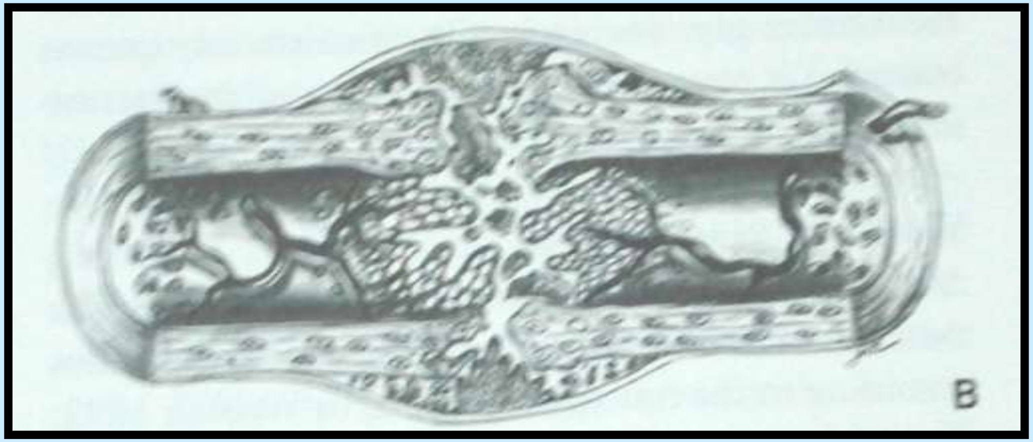
1) **Stage of inflammation- induction**
2) **Stage of fibrocartilaginous (soft) callus**
3) **Stage of hard callus**
4) **Stage of remodeling**

Stage of inflammation- induction



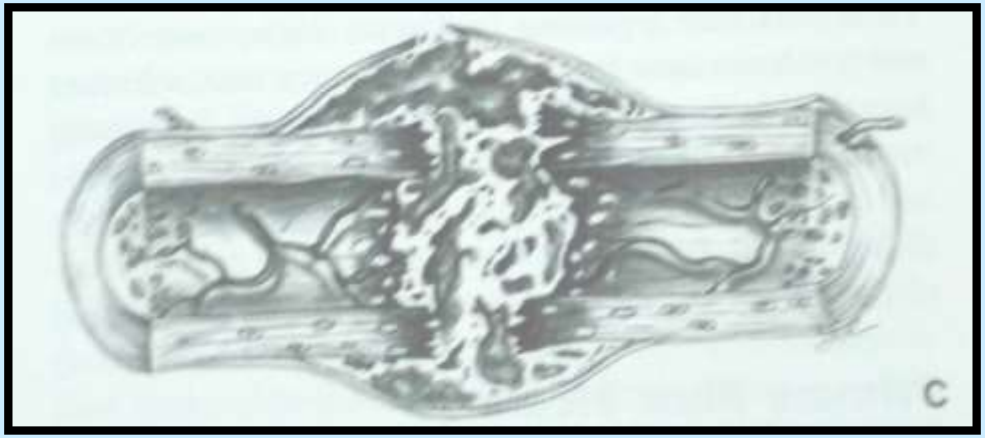
Fracture → hematoma formation → inflammatory cell & fibroblast migration → periosteal proliferation to form a bridge across fracture site → necrosis of bone at fracture ends

Stage of fibrocartilaginous (soft) callus



Organisation of subperiosteal hematoma → proliferation of osteoblast & fibroblast → formation of soft callus → collagen deposition & osteoid formation → immature woven bone formation

Stage of hard callus



New bone replaces callus → Endochondral bone formation → osseous union of fractured cortical bone

Stage of remodelling

Trabaculae orient themselves in the direct of functional stresses → later they orient themselves along the long axis of bone

POSTFRACTURE TIME	HISTOLOGY	PHYSIOLOGY
Immediate	Extravasation of blood	
24 hours	Aseptic inflammation → clot	
48 hours	Organization of the clot	
4 days	Intramembranous bone formation	Resorption of dead bone
	Subperiosteal bone formation	
	↓	
5 to 10 days	Hyaline cartilage	
	↓	
	Fibrocartilage + calcification	Remodeling of callus
	↓	
30 days until time of healing	Trabecular bone formation	
	↓	
	Cortical bone formation	

FIGURE 39-2 The sequence of histomorphologic changes during the healing of long bone fractures. (Modified and redrawn from Urist MR: Fundamental and clinical bone

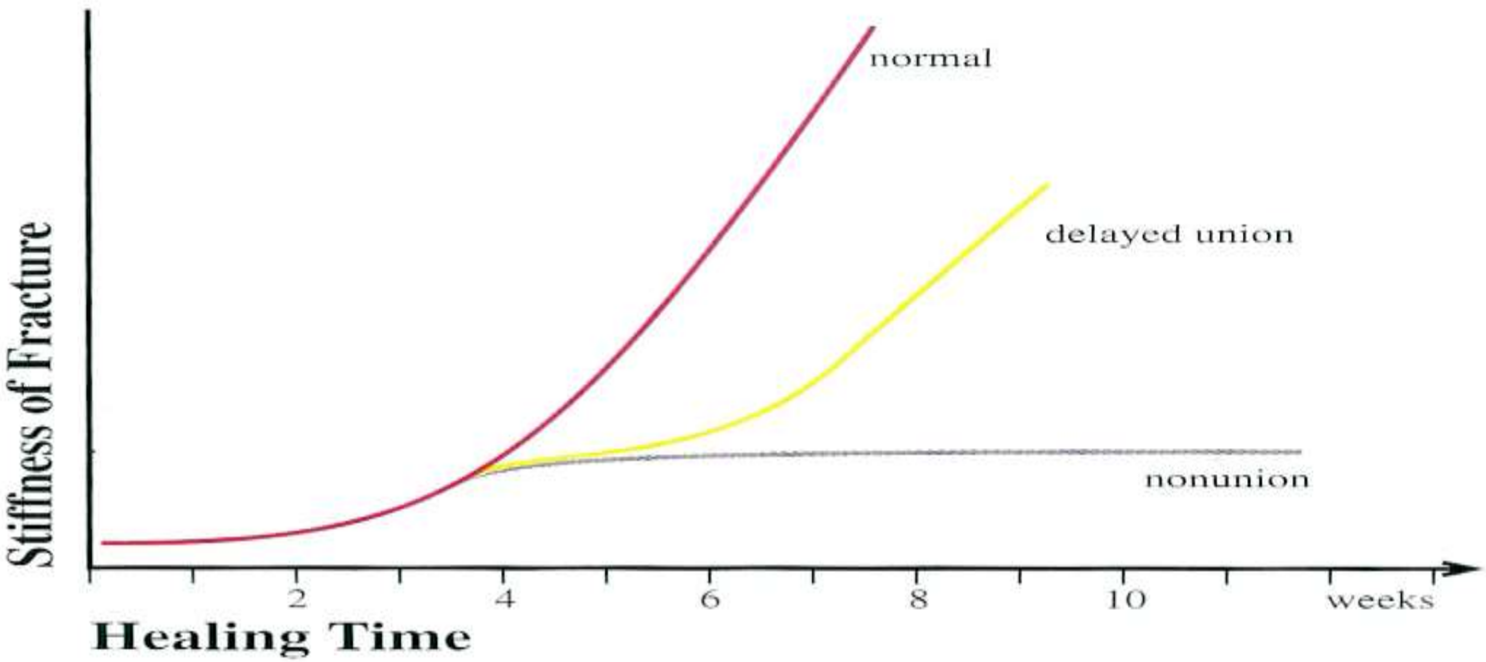


Fig. 1.5

Fracture healing: recovery of mechanical function. Initially a healing fracture presents low strength and low stiffness. During approximately the fourth to sixth weeks a dramatic change in mechanical properties occurs towards the properties of normal bone. In an undisturbed situation mineralization across the fracture plane takes place at this time. If the loading of the mineralizing fracture does not exceed certain limits, healing proceeds normally. Undue loading of such a uniting fracture at a critical moment may disturb the mineralization process and lead to a delay in bony union, or, if compensatory healing mechanisms fail, to a nonunion.

Re-establishing stability

GOALS OF OPERATIVE TREATMENT:

-Early anatomical reduction of the fractured fragments

-Maintaining position after reduction

-Guaranteeing union in the desired position

AO/ASIF Principles :

Arbeitsgemeinschaftfur osteosynthesefragen or Swiss Association for the study of internal fixation was founded in 1958 by Maurice A. Muller et al.

Postulated in 1958

1. Anatomic reduction
2. Stable internal fixation
3. Atraumatic surgical technique
4. Early pain free mobilization.

Indication of RIF :

- Patient non compliance
- Substance abuse
- Airway considerations
- Esophageal – gastric reflux syndromes, including bulemia
- Obstructive pulmonary disease
- Psychiatric disorders
- Fracture displacement
- Compound fractures
- Patient preference

CONTRAINDICATION OF RIF

- Heavily communited fracture, where open reduction may pose risk of compromising vascularity.
- In children having mixed dentition, where there is danger of injuring developing tooth buds.
- Presence of gross pathological abnormalities

ADVANTAGES OF RIF

- Simple technique
- Decreased intra-operative time
- Post op IMF not needed or period of IMF reduced
- Early return of function
- Better esthetics & function
- Better 3D stability
- Psychological advantage
- No nutritional deficits
- No wt. loss or speech problems

Clinical Requirements

- adequate strength & rigidity
- lack of adverse reactions
- lack of interference with bone healing
- lack of intracranial migration
- lack of visibility and palpability
- avoidance of an implant removal operation
- lack of imaging interference
- good handling properties such as plate malleability and good torsional strength of screws

BIOMECHANICS OF FACIAL SKELETON

Mandibular fractures :

- **Simple beam mechanics**

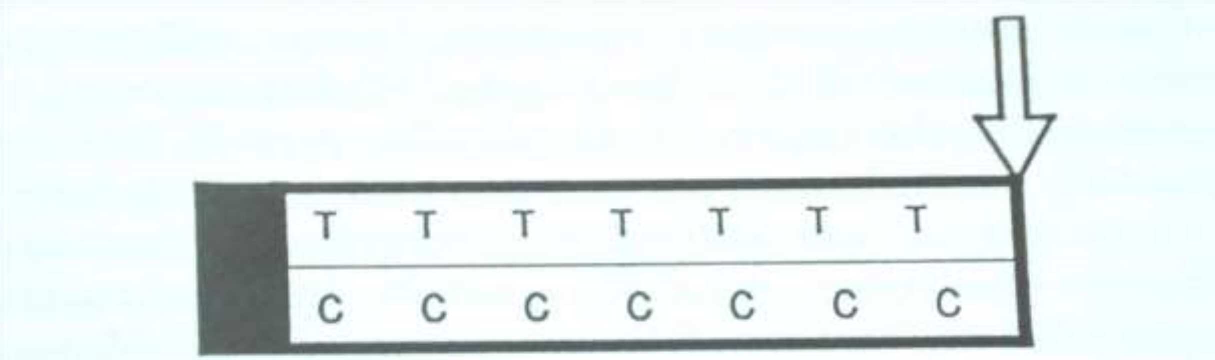


FIGURE 39-5 Simple beam mechanics illustrating tensile

Mandible is class III lever with condyle acting as fulcrum, levator muscles as applied forces & bite load as resistance forces. So when a load is applied to occlusal surface, a tension zone along alveolar ridge, compression along lower border & neutral zone along inferior alveolar nerve found. But this theory does take into account forces generated by contralateral musculature

Action of muscles

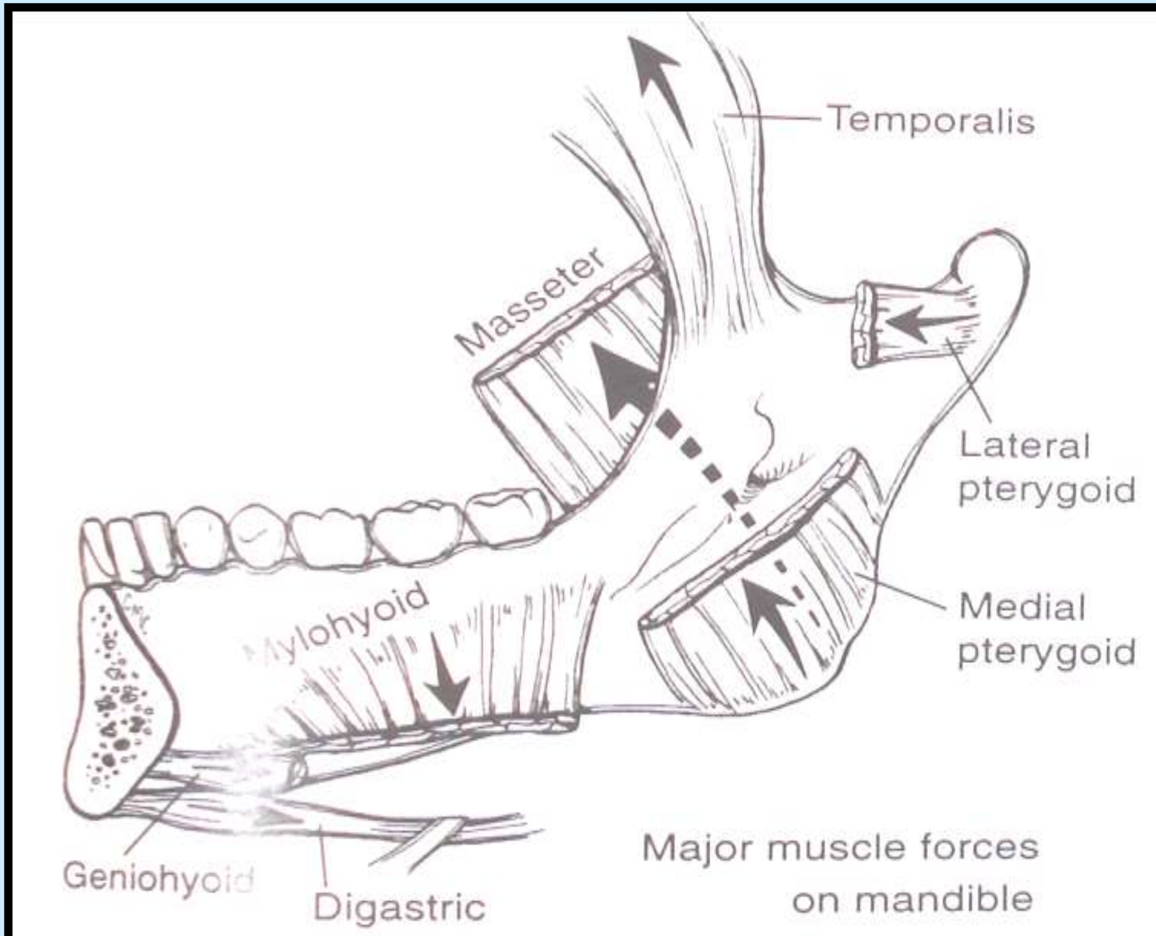


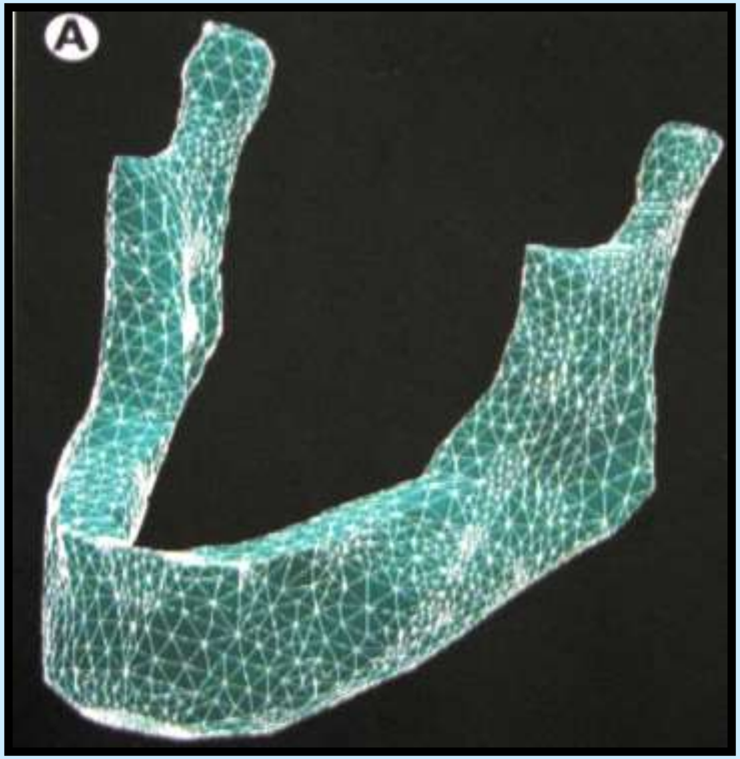
Figure 5.18. Diagram indicating muscles of mastication and their vectors of force during contraction.

Finite element analysis

Three-dimensional finite element analysis can be used for finding :

Variation in the thickness of mandible, material density changes & complex geometry of the mandible.

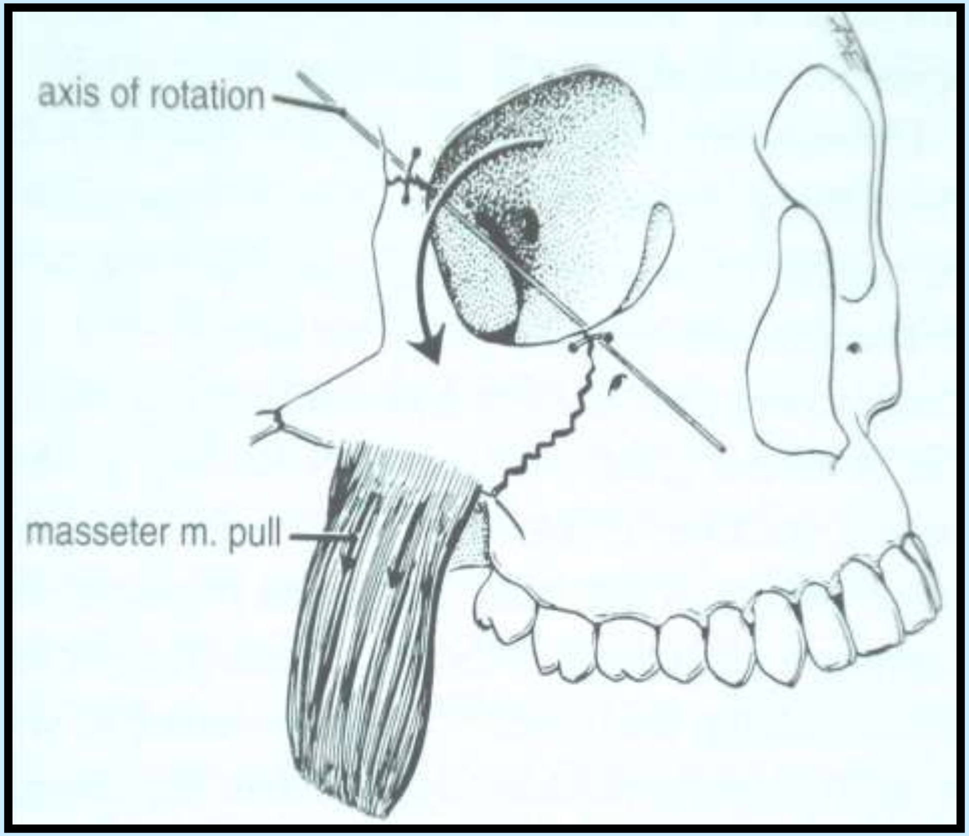
The effects of the masseter, pterygoid, and temporalis muscles can be recreated using rod elements that duplicated both the direction of force and attachment area of the muscles.

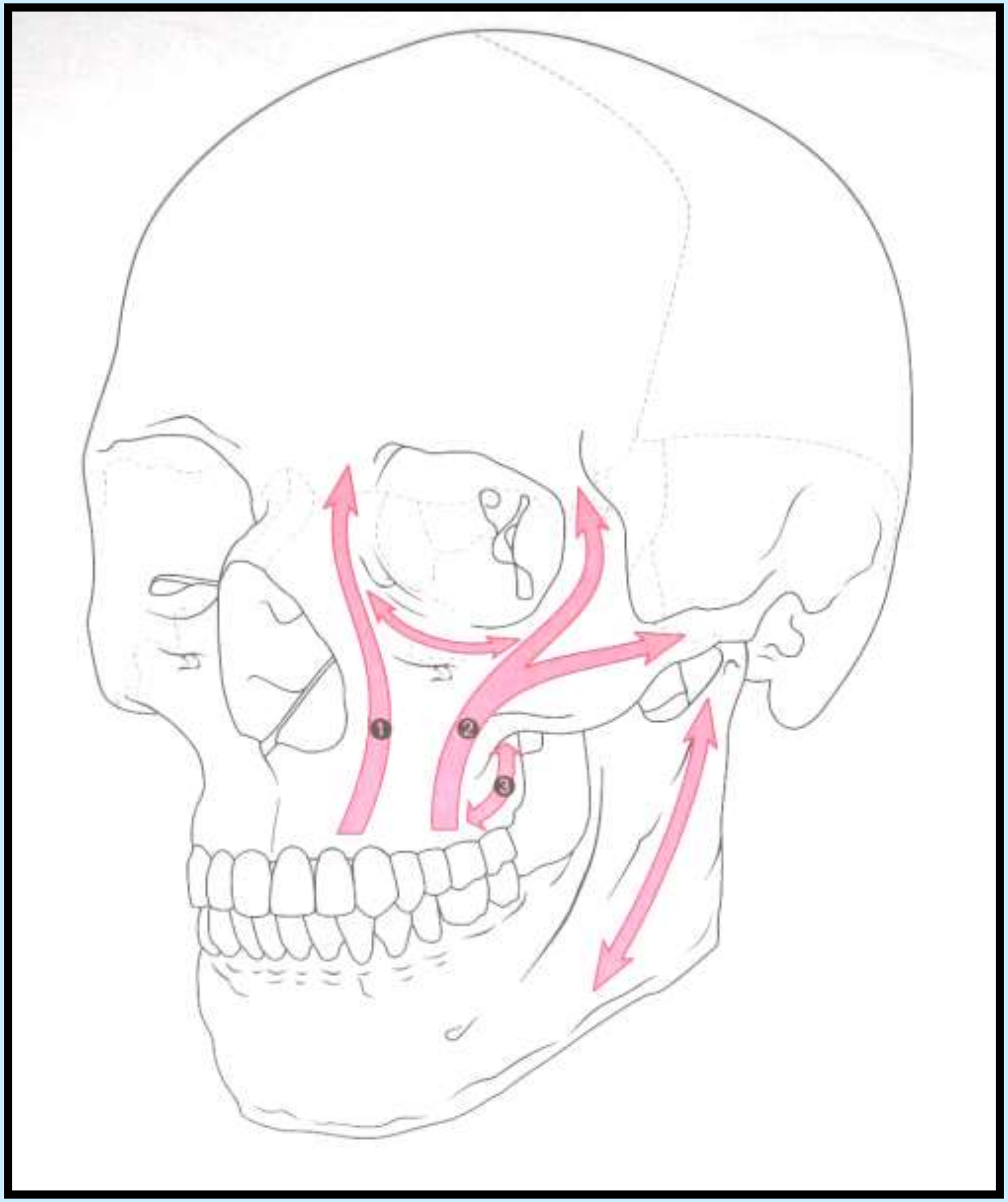


- For mandibular body & parasymphysis fracture, simple beam mechanics seem to correlate with finite element analysis when describing bite forces applied anterior to the fracture site.
- However finite element analysis demonstrates reversal of the tension compression zone, when the applied bite forces are employed posterior to the fracture line or muscular axis. This reversal of tension & compression may also occur, if the bite force is applied just anterior to the fracture when the activity of the contralateral muscle sling predominates.

MID FACIAL FRACTURES

- In bones of midface, only zygoma fracture has significant instability due to masseter muscle pull however temporalis fascia opposes this pull.
- FZ – Most strongest pillar. Tensile forces are greater. Most important point of fixation




1
2
3

PRINCIPLES OF RIGID FIXATION :

Rigid fixation techniques for bone repair are based on several principles and premises.

- A screw of proper strength and design will hold in bone over time.
- A properly designed and properly positioned rigid plate will impart its strength to a fractured or osteotomized bone when it is properly fixed to that bone with screws.
- Devices can be fixed to fractured and osteotomized bones so that the bones remain fixed together despite full loading in function.

- Additional fixation points generally yield a stronger fixation.
- If the rigid fixation device is strong enough, and if enough fixation points are used, a bone defect can be bridged with the fixation device so that the remaining segments can support a functional load.
- Corollary : A rigid plate screwed on the fracture segments will not impart stability, unless
    - The fixation device is appropriate for the particular anatomical and physiological need.
    - The number of fixation points is adequate and
    - There is strict adherence to biomechanical principles.

The key to successful rigid fixation (i.e., maximizing successful outcomes and minimizing complications and failures) is combination of:-

- Knowledge of the biomechanical principles that form the basis for rigid fixation techniques and
- Adherence to these principles to whatever extent is possible.

METALLURGY :

1. Stainless steel :

composition

Iron – 62.5%

Chromium – 17.6%

Nickel 14.5%

Molybdenum – 2.8%

- Corrosion resistance and compatibility – fair.
- Corrosion is seen when one metal component frets against another metal component (fretting corrosion)

2. Titanium :

- Extremely insoluble and consequently inert and biocompatible.
- best corrosions resistance and biocompatibility. Low modulus of elasticity but greater than that of bone.
- least interference with MRI and CT scans.

3. Vitallium :

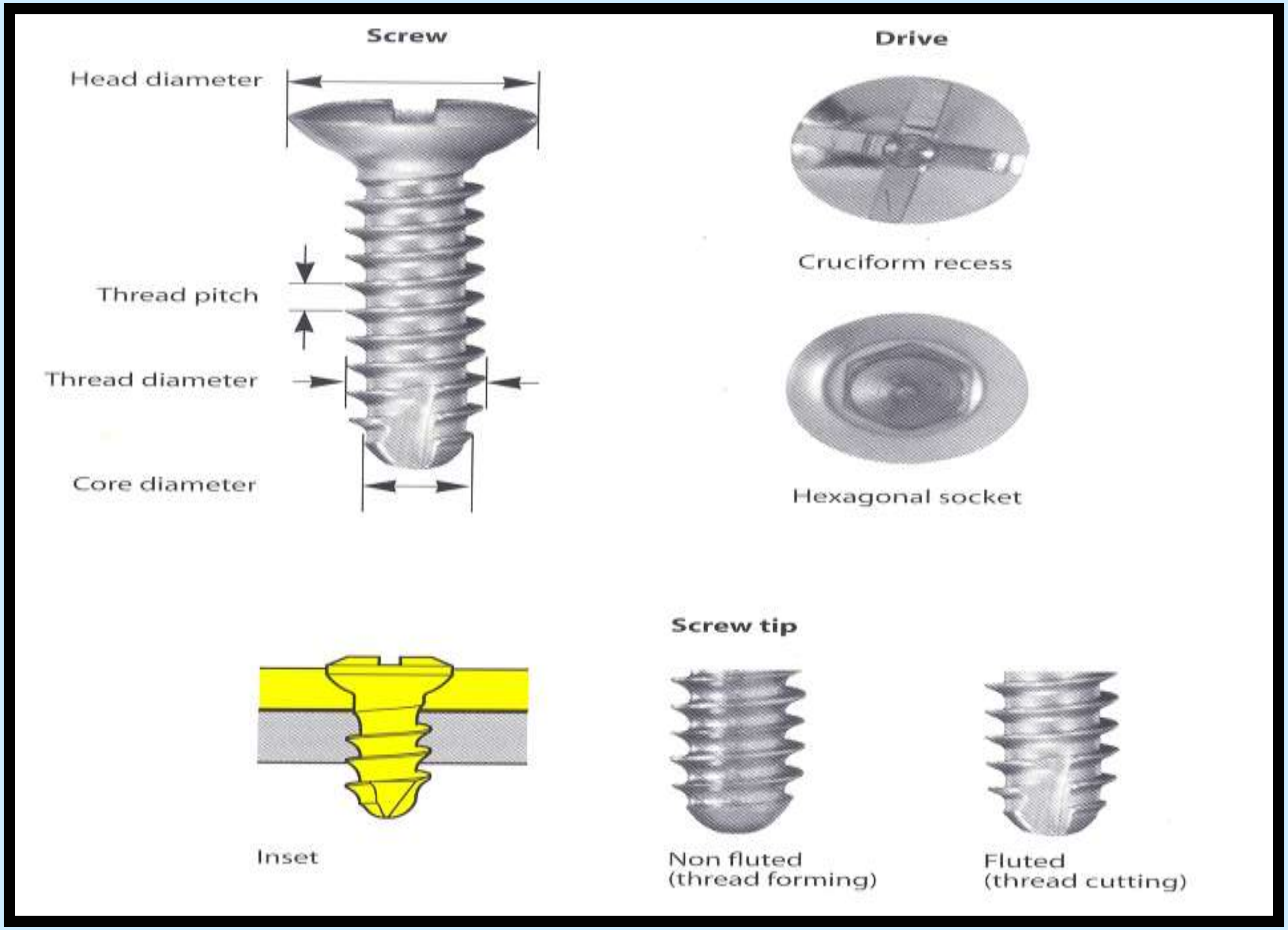
- Contains cobalt, chromium and molybdenum.
- Tensile strength greater than titanium

4. Bioresorbables :

- Attempts to use bioresorbable materials, such as the various polyesters used in resorbable sutures, for the fixation of bones date back at least three decades.
- Despite the testing and successful utilization of a wide variety of these materials (e.g. polylactic acid, polyglycolic acid, and polyparadiaxanone) in animals and in humans, complication rates continue to be unacceptably high.

Armamentarium for RIF

1. screws



Screw	Thread (Ø in mm)	Core (Ø in mm)	Pitch (Ø in mm)	Head (Ø in mm)	Drive
					
Standard screw	2.0	1.4	1.0	3.5	
Emergency screw	2.4	1.7	1.0	3.5	
					
Standard screw	2.4	1.7	1.0	4.0	
Emergency screw	2.7	1.9	1.0	4.0	
					
UniLOCK screw 2.4	2.4	1.7	1.0	4.0	
UniLOCK screw 3.0	3.0	2.4	1.0	4.0	
Emergency screw	Not existing				
					
Standard screw	2.7	1.9	1.0	5.0	
Emergency screw	3.2	2.1	1.25	5.0	
					
THORP screw	4.0	3.0	1.25	4.5	
Emergency screw	Not existing				

Types

1. According to the compression applied

a) Compression screws

b) Positional screws

2. According to design of the thread

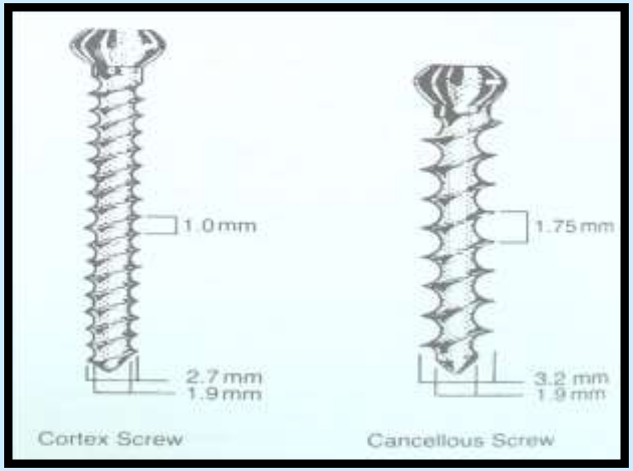
a) Machine screw

b) ASIF screws

i) cortical (1.5 – 4.5 mm)

ii) cancellous (4.0 – 6.5 mm)

iii) malleolar (4.5 mm)



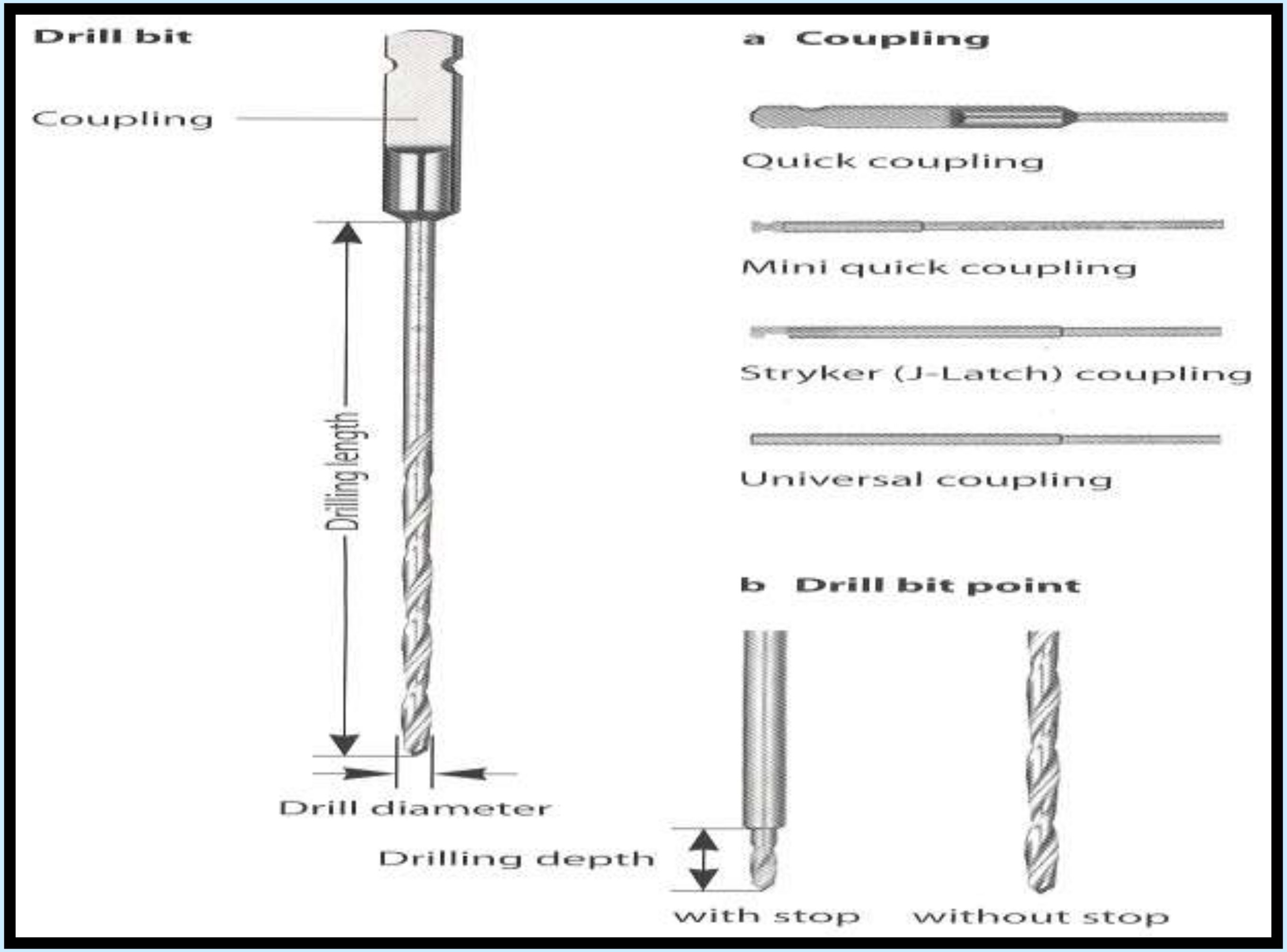
3. According to the ability to drill holes

a) self tapping

b) non self tapping

Instruments for screw insertion

1. Drill bit

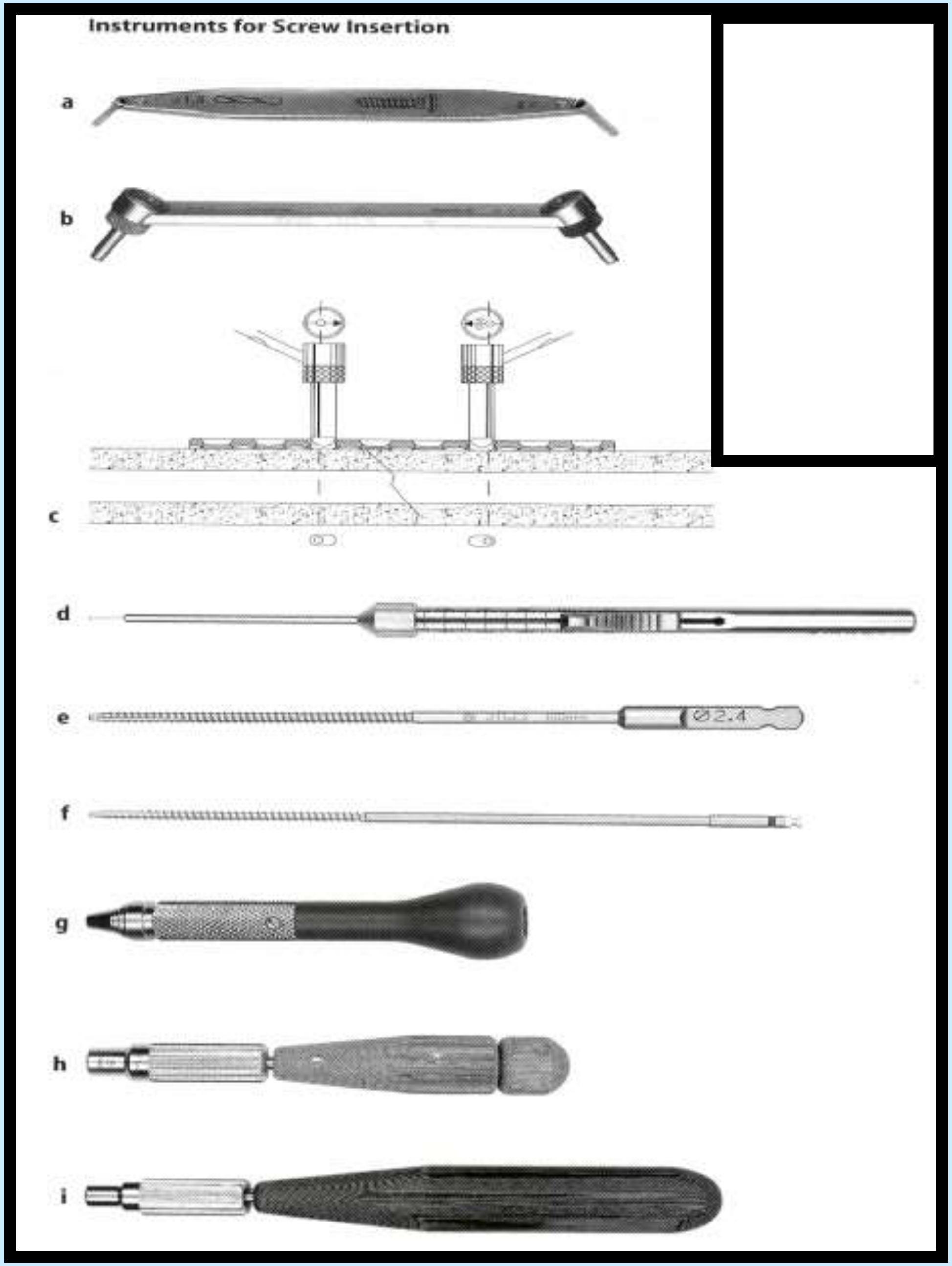


2. Drill sleeves

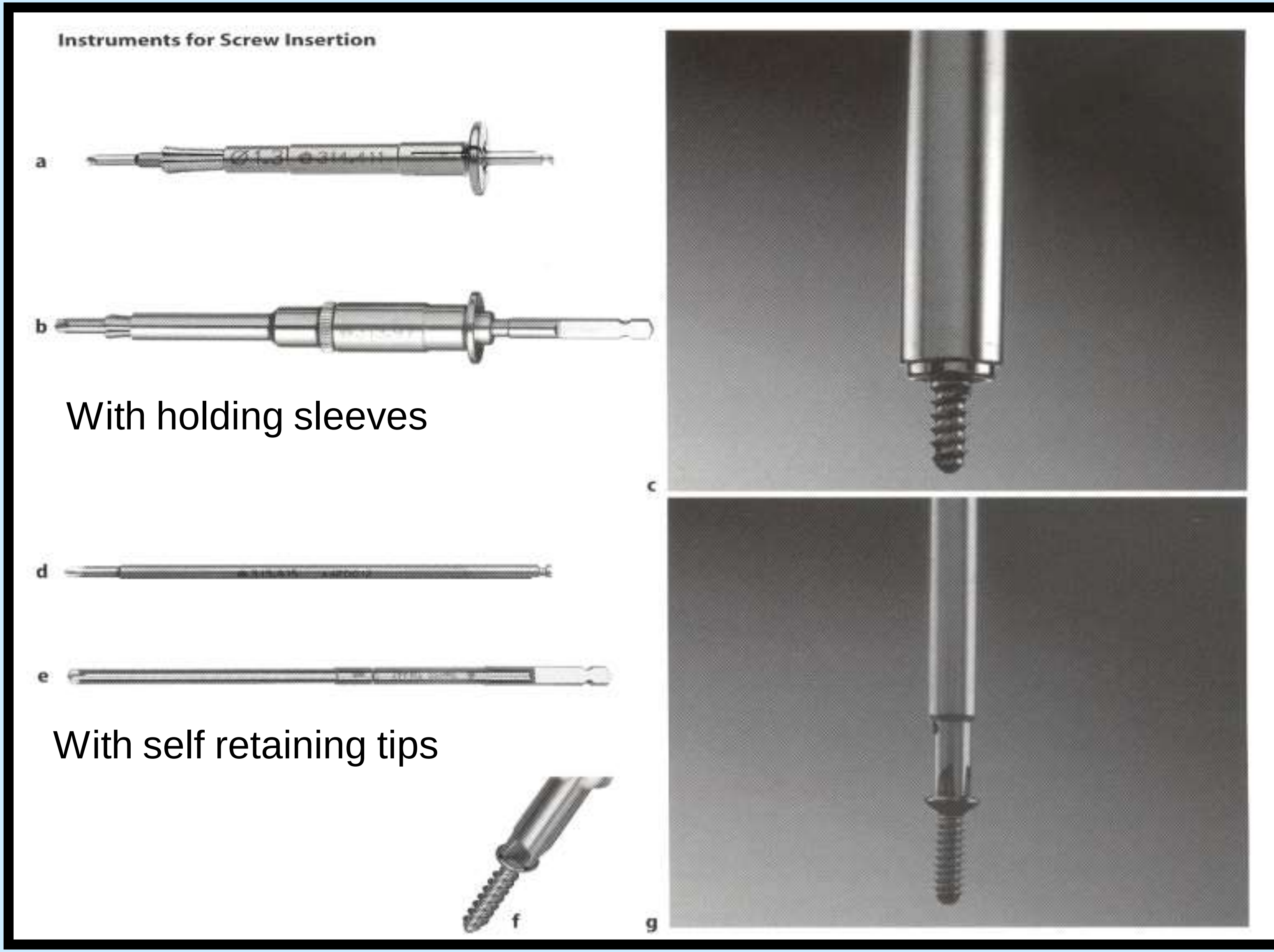
3. Drill guides

4. Depth gauges

5. Taps



6. Screw drivers



Plates

1.Craniofacial plates

Different forms :-

a) X plate

b) Y plate

c) double Y plate

d) L plate

e) T plate

f) H plate

g) box or frame plates

h) orbital rim plate

i) straight plate

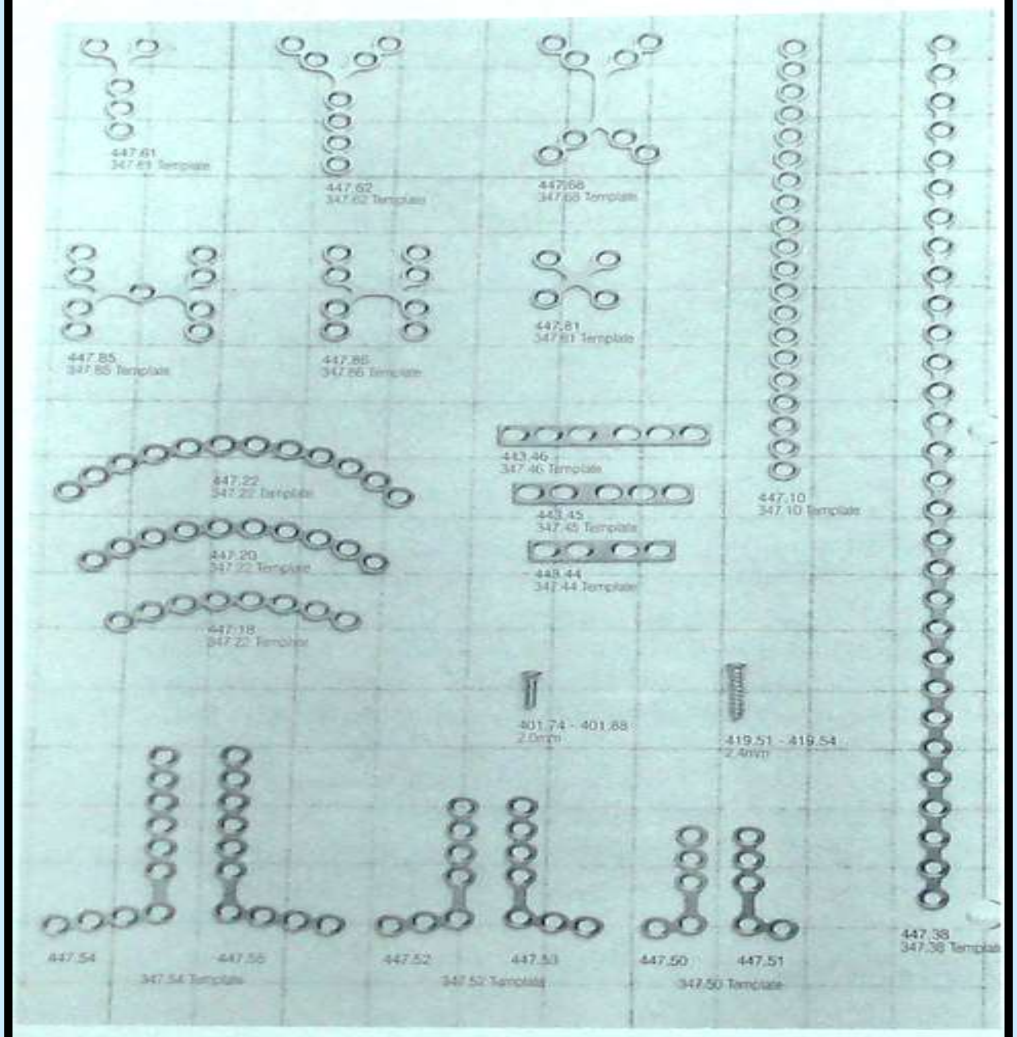


Figure 8.4. The 2.0-mm implant system has a number of different plate designs to adapt to virtually any clinical problem. (Courtesy of Synthes Maxillofacial, Paoli, PA.)

Special craniofacial plates

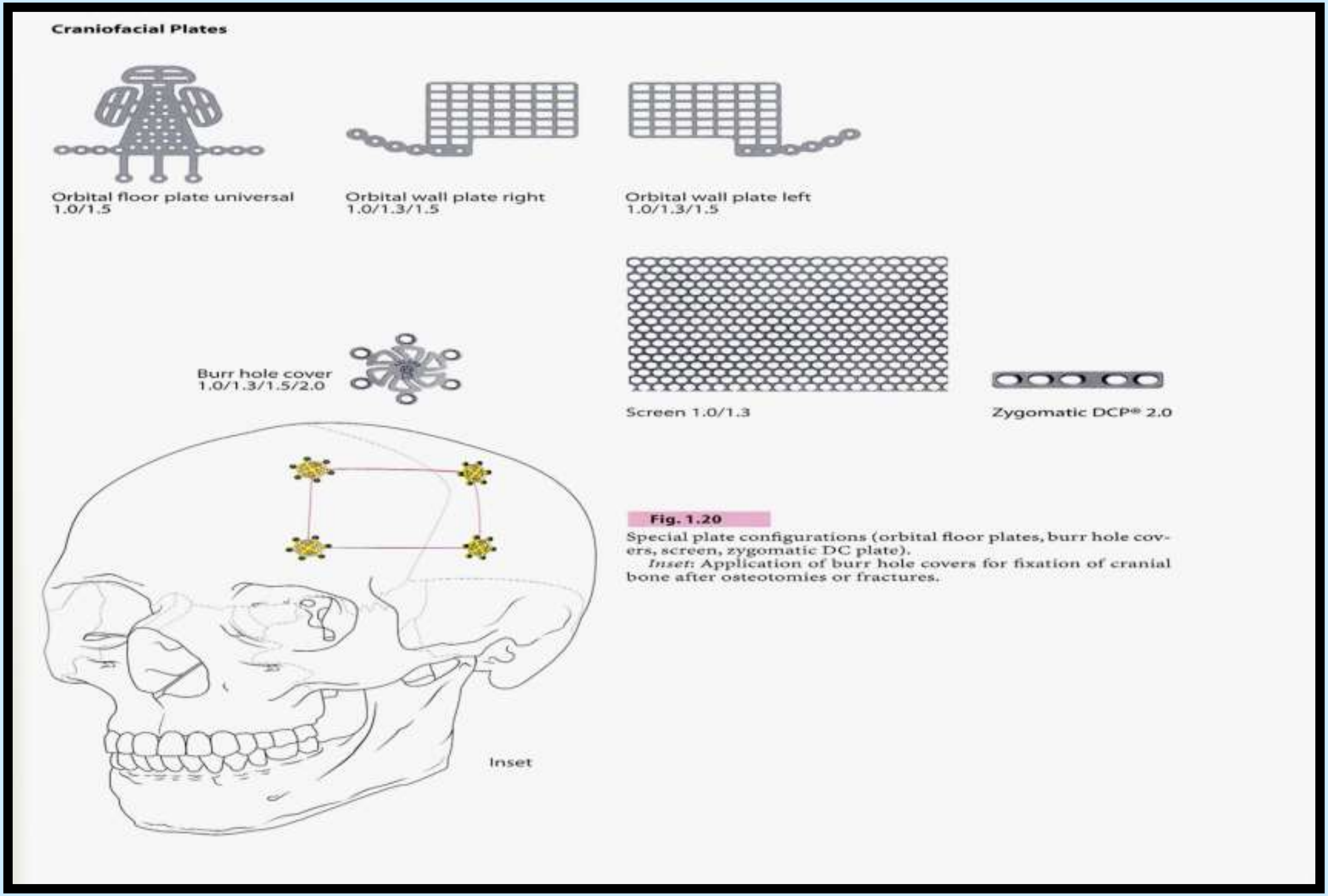
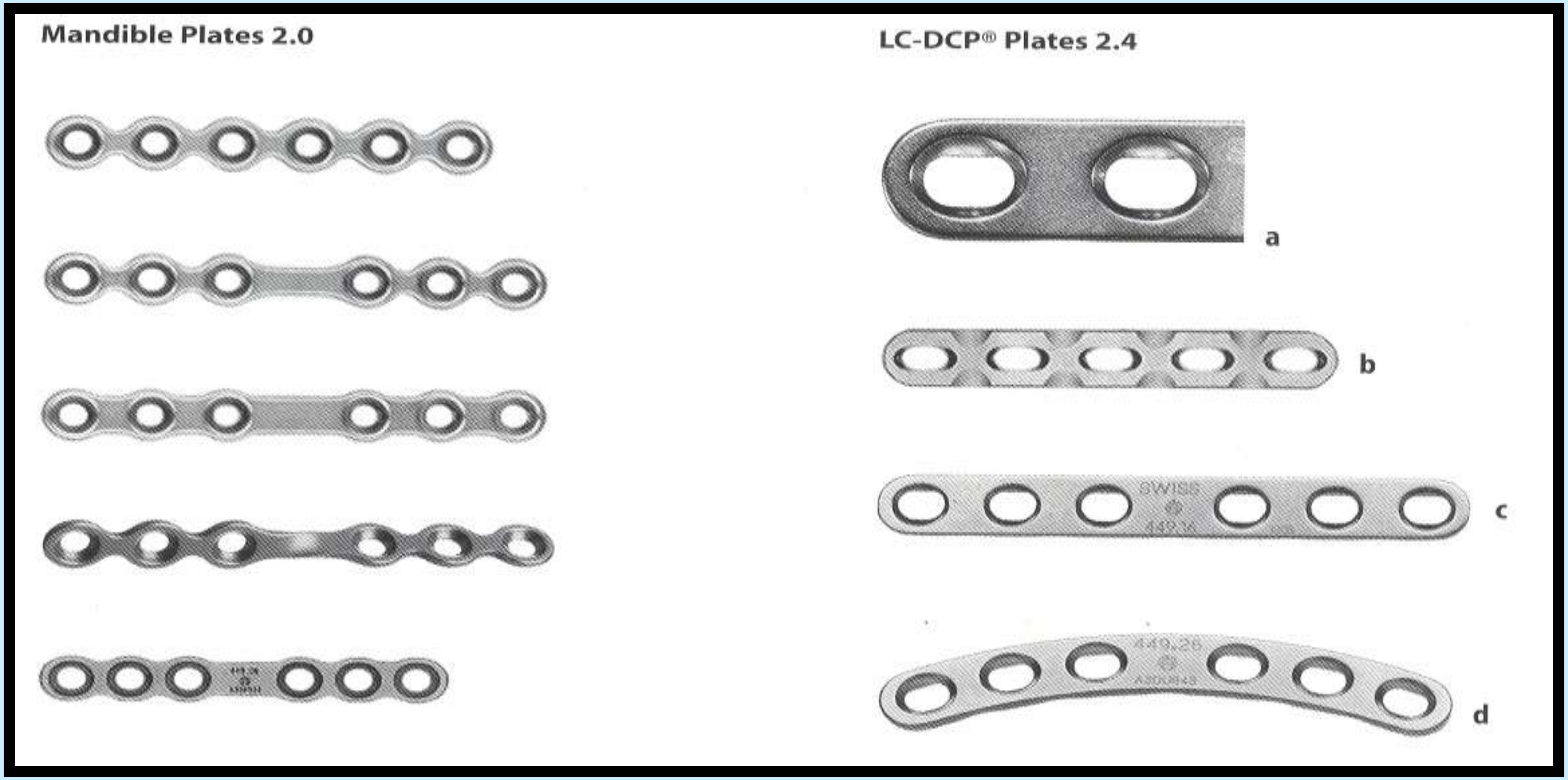


Fig. 1.20

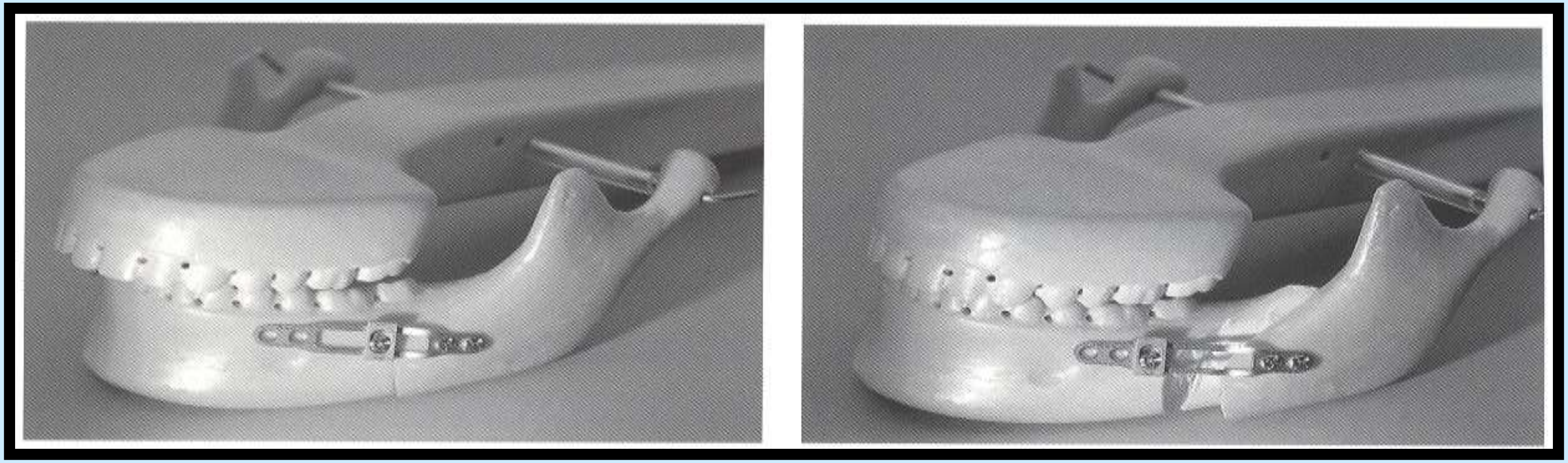
Special plate configurations (orbital floor plates, burr hole covers, screen, zygomatic DC plate).

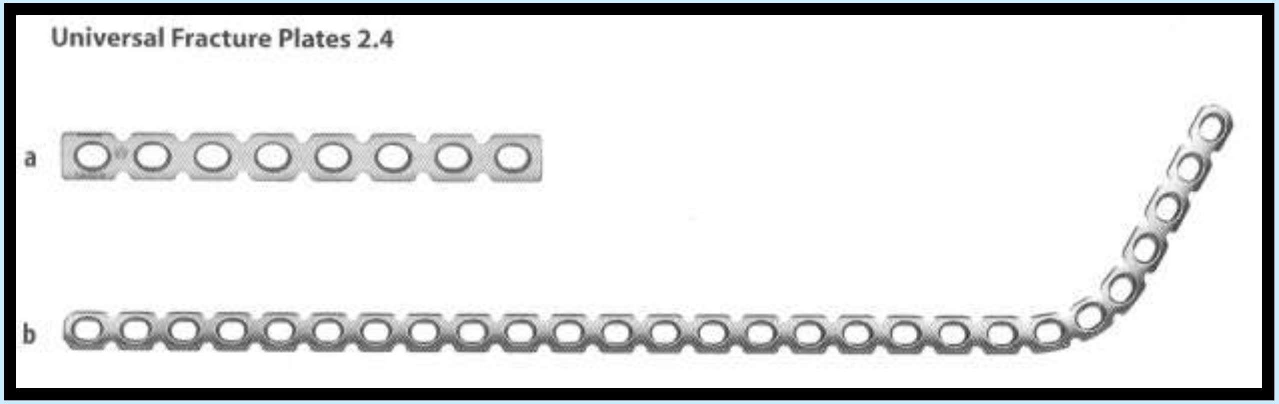
Inset: Application of burr hole covers for fixation of cranial bone after osteotomies or fractures.

2. Mandibular plates



Special mandibular plates

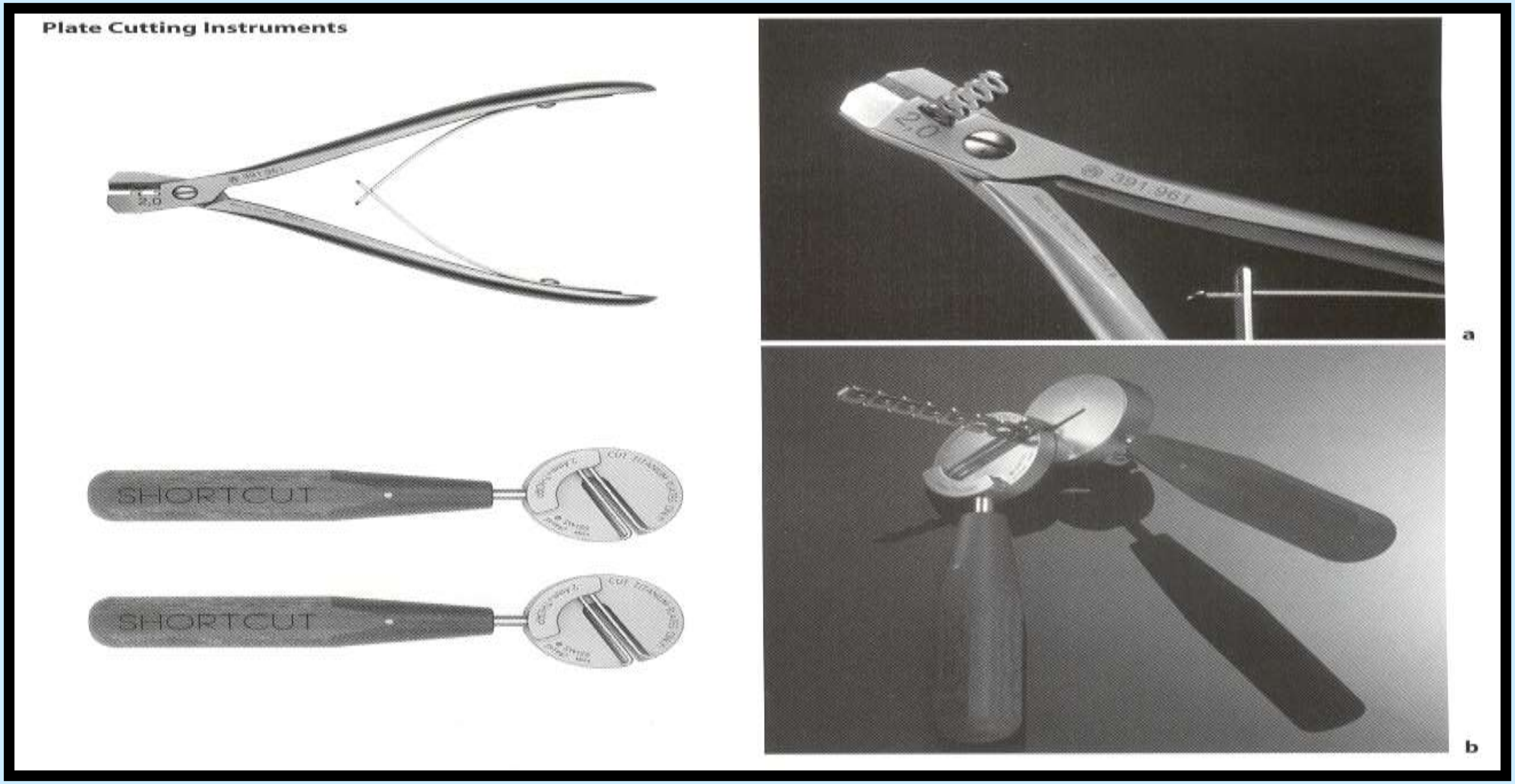




THORP Reconstruction Plates 4.0

Reconstruction Plates 2.4

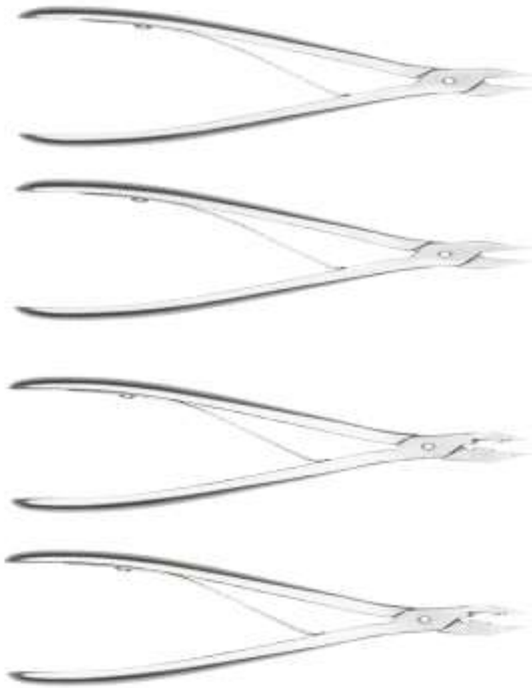
Plate cutting instruments



a Plate cutting forceps for all plates from 1.0 to 2.0.
b Plate cutter for 2.4 plates and THORP reconstruction plates (Shortcut™ 2.4/THORP). The device must be used in pairs.

Plate bending instruments

Bending Instruments for 1.0–2.0 Plates



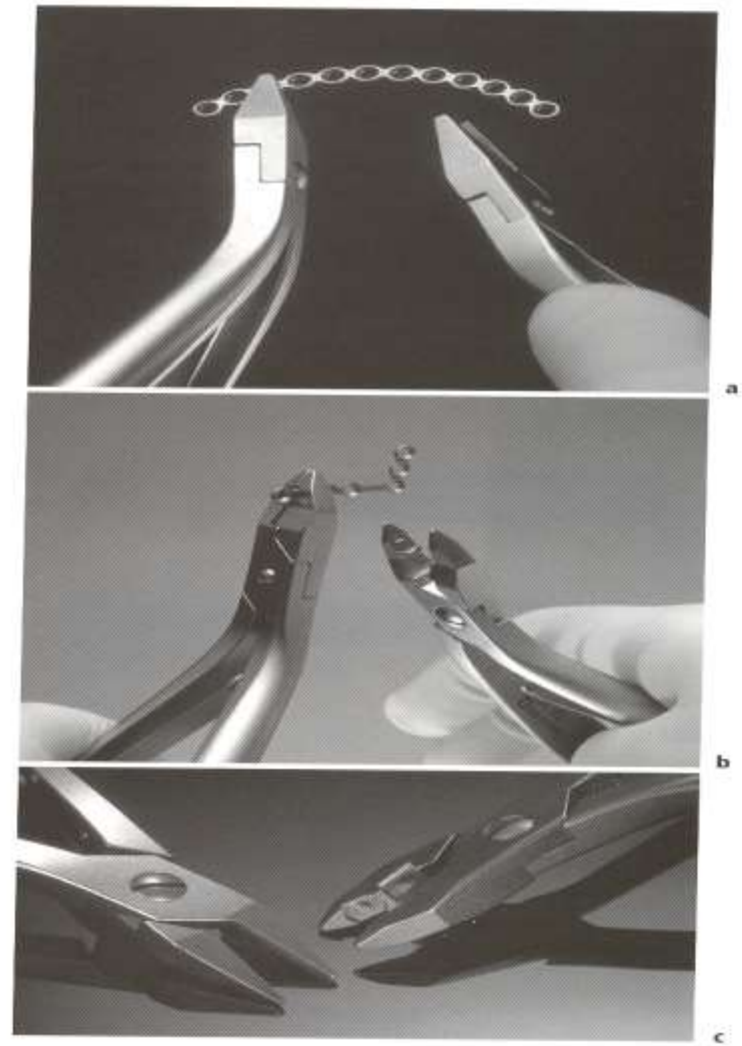


Fig. 1.31 a–c

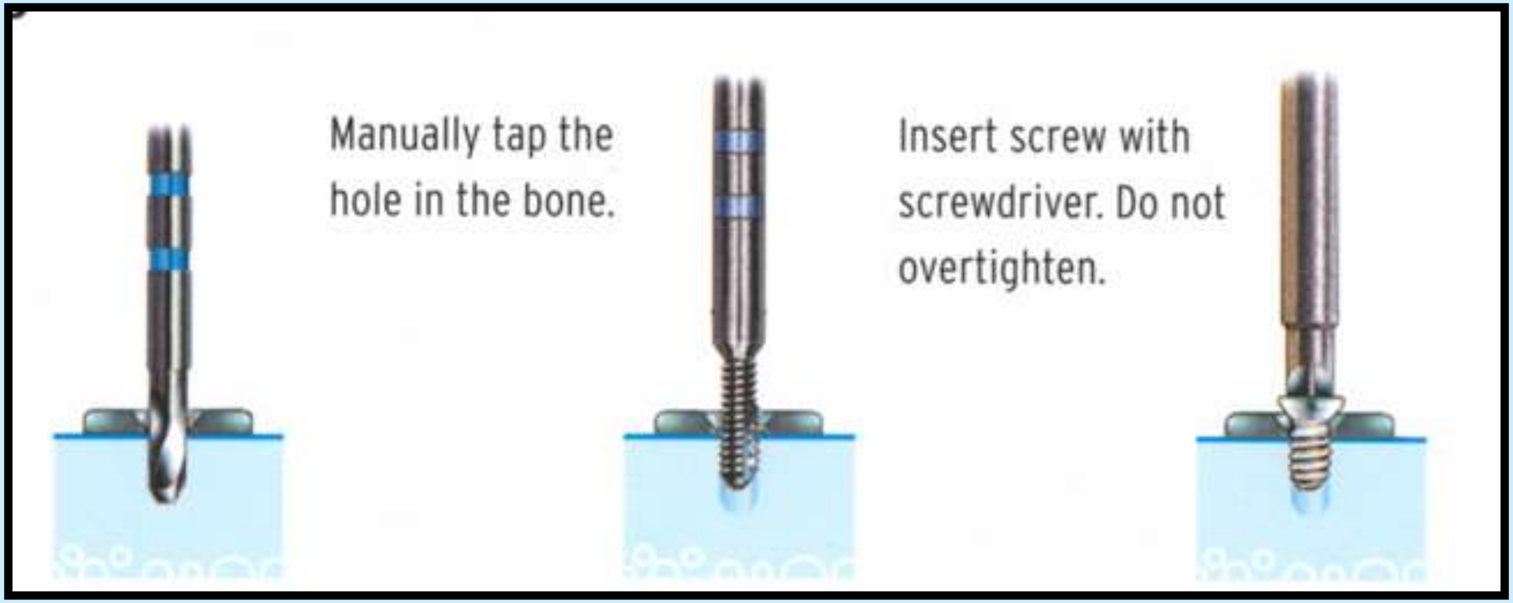
a Pair of bending pliers, pointed, for 1.0 to 2.0 plates.

b Pair of bending pliers with special inset for the plate hole, thus preventing the deformation of the plate hole during bending.

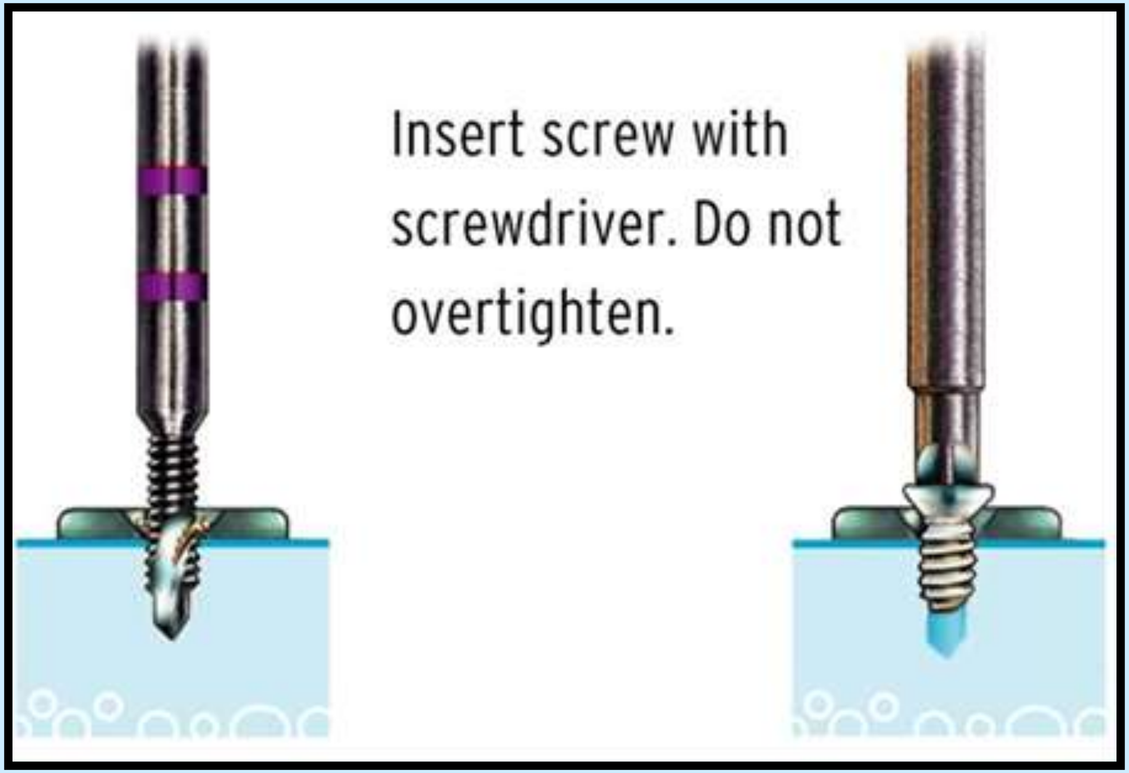
c *Left*: close up of mouth of bending pliers shown in **a**. *Right*: mouth of bending pliers shown in **b**.

Screw Insertion Methods

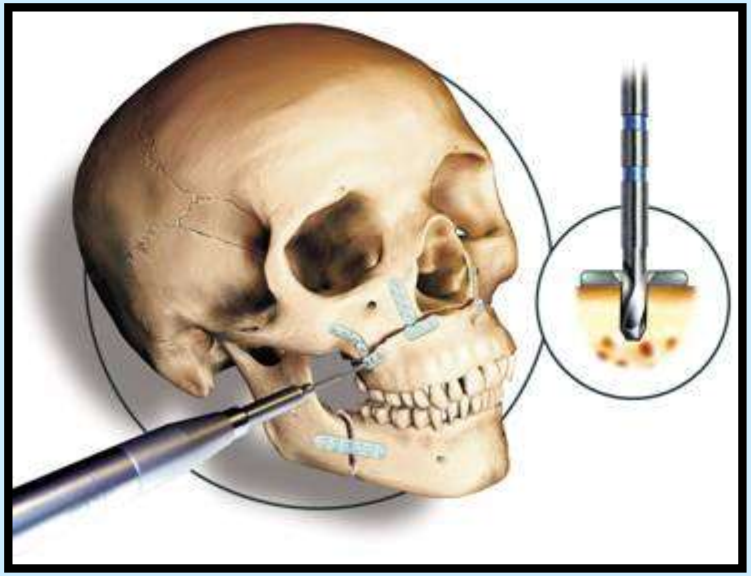
1. Manual Tap



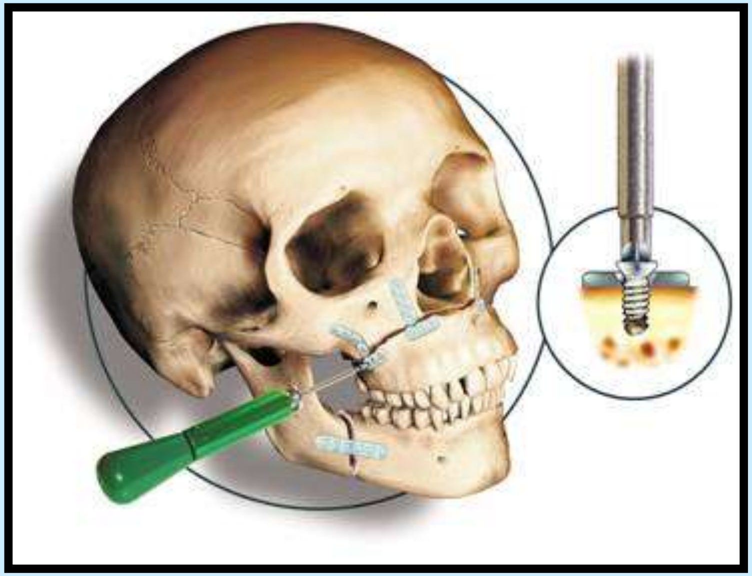
2. Self Tapping Drill



3. Self-tapping screw

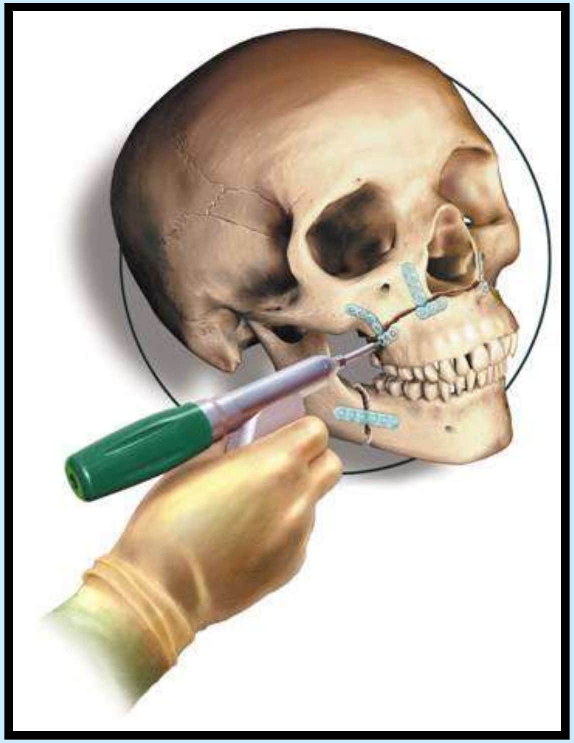


Drill hole



Insert screw with screwdriver.
Do **NOT** overtighten.

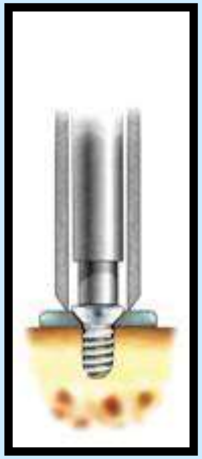
4. Tacker



Drill a hole

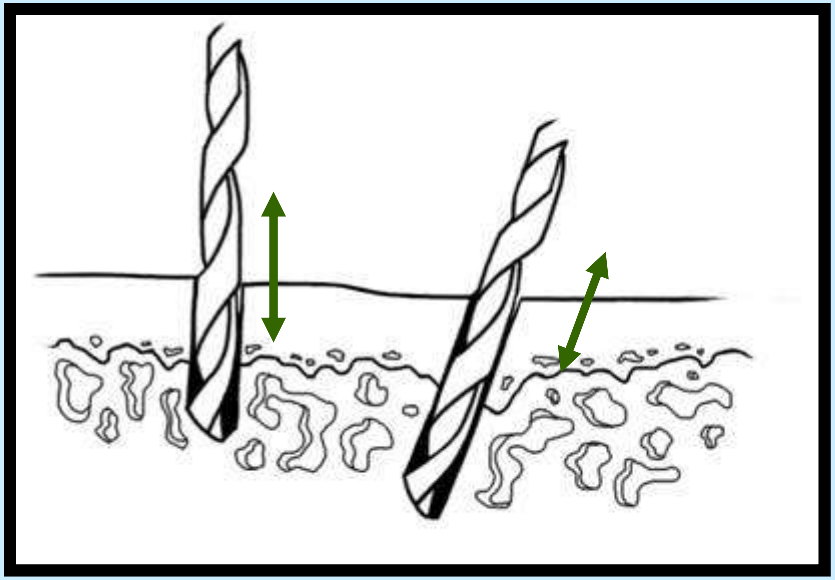
Aim

Align



Fire

Drilling



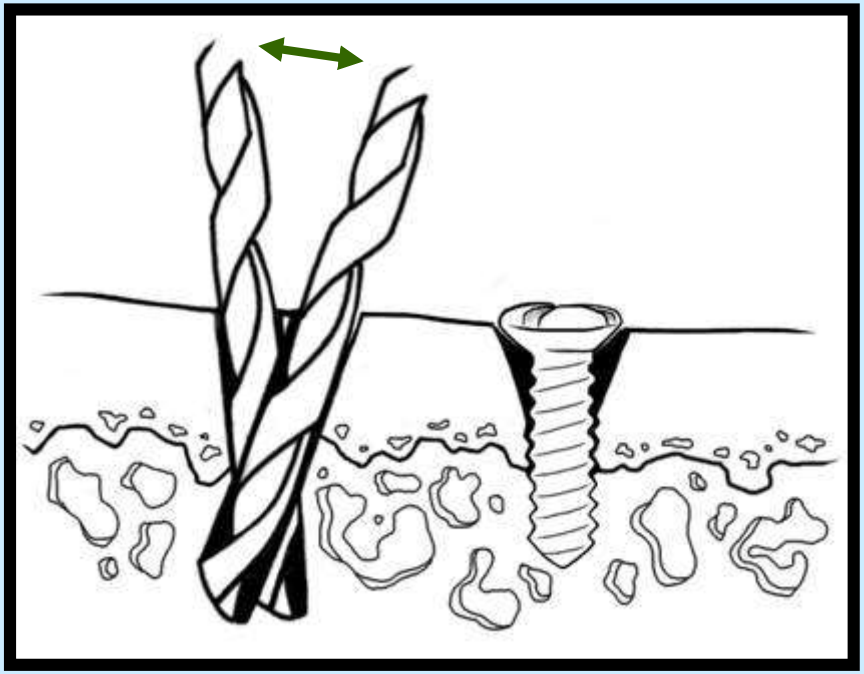
Successful osteosynthesis depends on quality of holes drilled

Accurate drilling is top priority

Hole need not be exactly perpendicular to the plate surface, it must be stricly monoaxial.

After drilling 3 – 4mm deep into healthy bone, a decrease in resistance will be felt, indicating that the cancellous bone layer has been reached. Stop drilling.

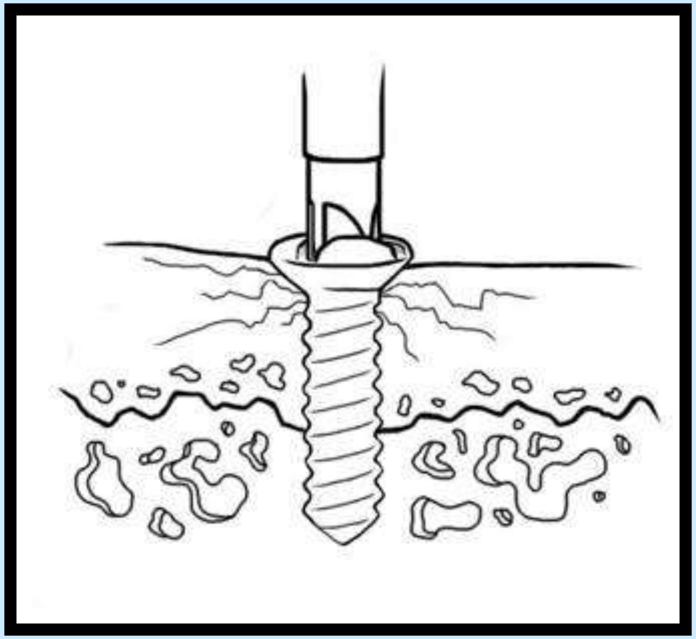
Drilling



Any change in the drilling angle during the drilling procedure will invariably result in a conical hole and thus reduce the number of threads finding adequate purchase in the bone.

During the entire drilling procedure, provide continuous irrigation to avoid thermal necrosis.

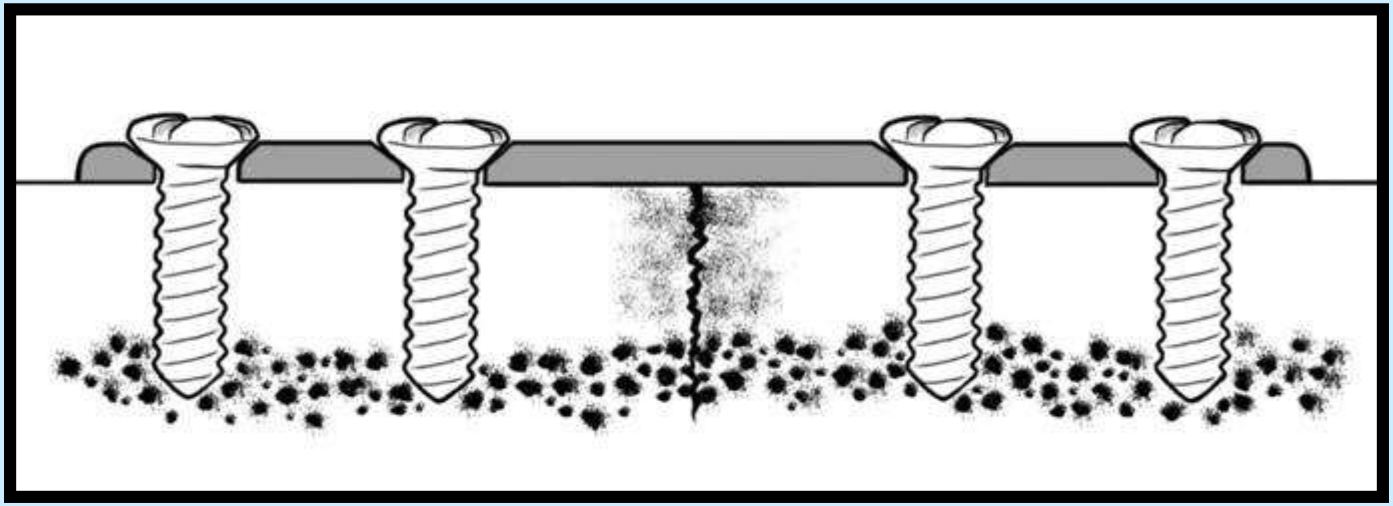
Screw Tightening



When tightening the screw in the bone, care must be taken to not use too much force to avoid destruction of the bone threads.

Each plate must be anchored by at least 2 screws on either side of the fracture site.

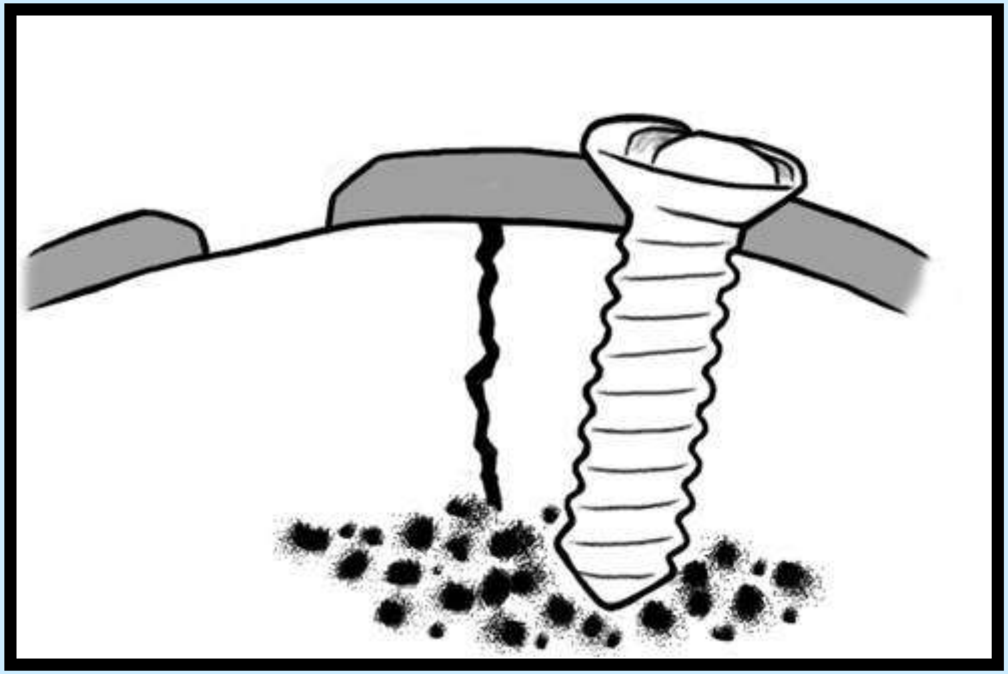
Screw Anchorage



Should the screw anchorage in the outer cortex be suspect, the drilling should be continued though the inner cortex and a longer screw inserted for bicortical fixation.

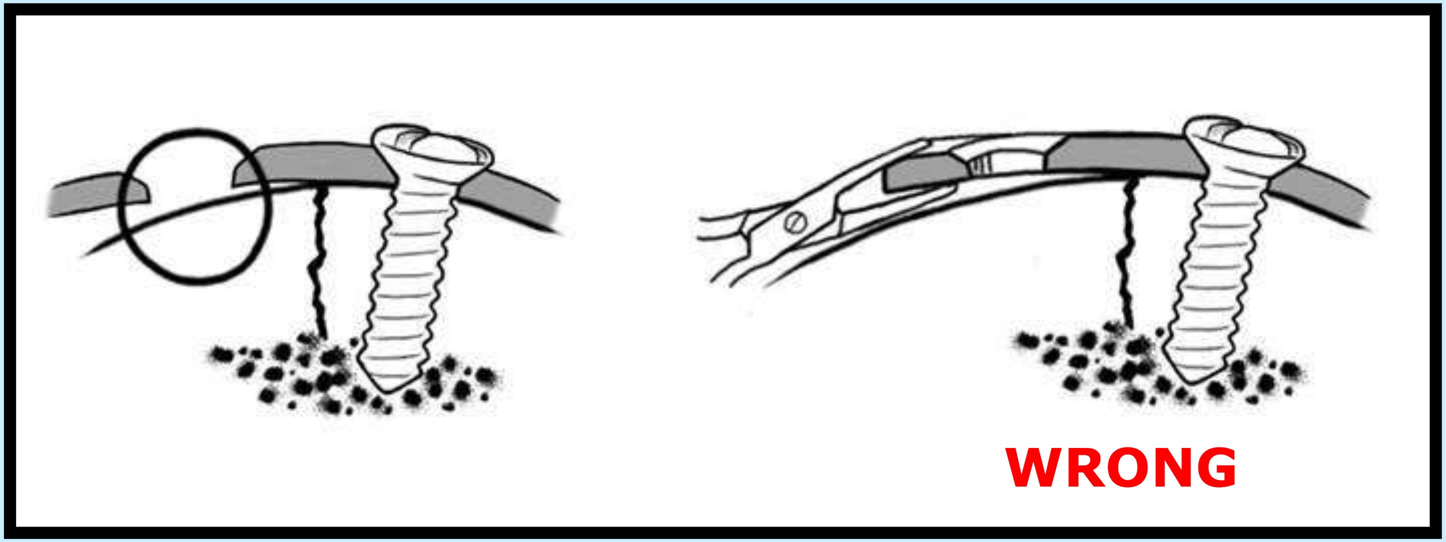
Another alternative would be to use a ”spaced” plate and drill new holes as required.

Plate Adaptation



It is crucial that the plate be congruent to the bone surface before anchoring it by means of the screws.

Plate Adaptation



Once one or several screws have been inserted, no attempt should be made to improve on the shape of the plate. Such an attempt would result in the loosening of the screws already fastened.

Compression osteosynthesis :

Goal – absolute stability in which no movement occurs at the area of interfragmentary contact or between the bone and fixation device.

Enhances the likelihood of successful primary bone healing in two ways:-

a) Pre load – is the force generated across the fracture by the fixation system.

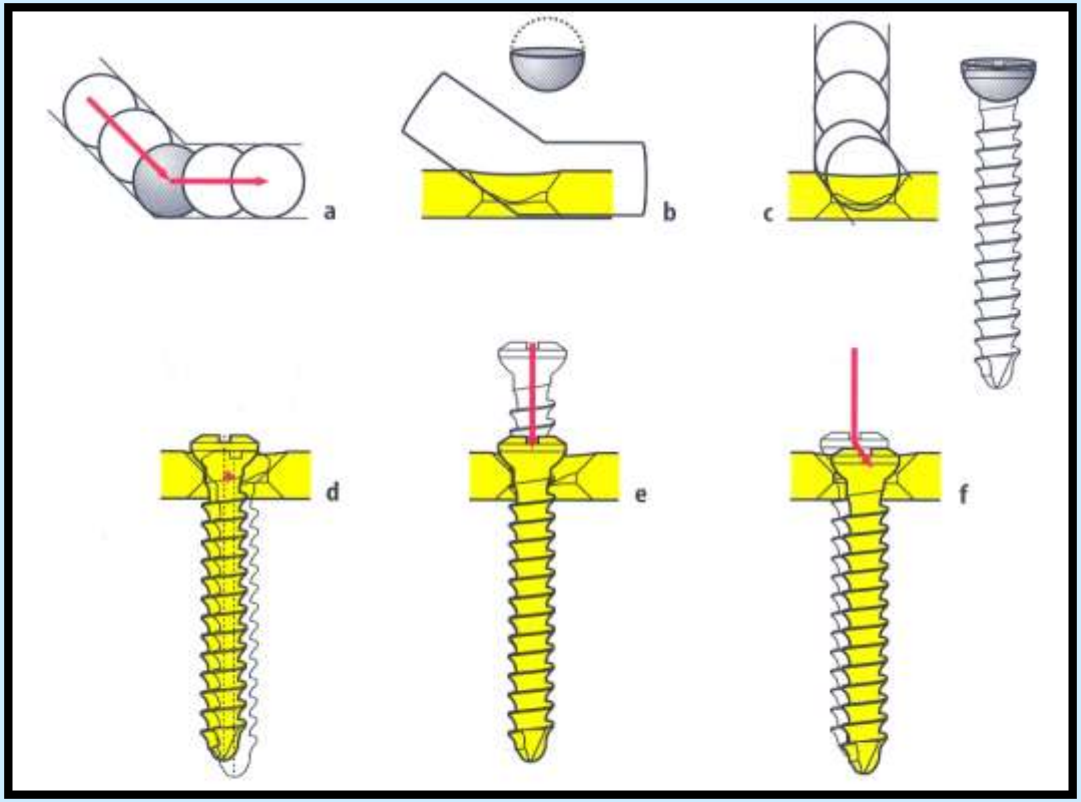
b) Friction produced by compression of the fractured bone segments.

Maximal compressive force generated from compression plates is 300 kilopascals /cm^2.

Dynamic compression plates :

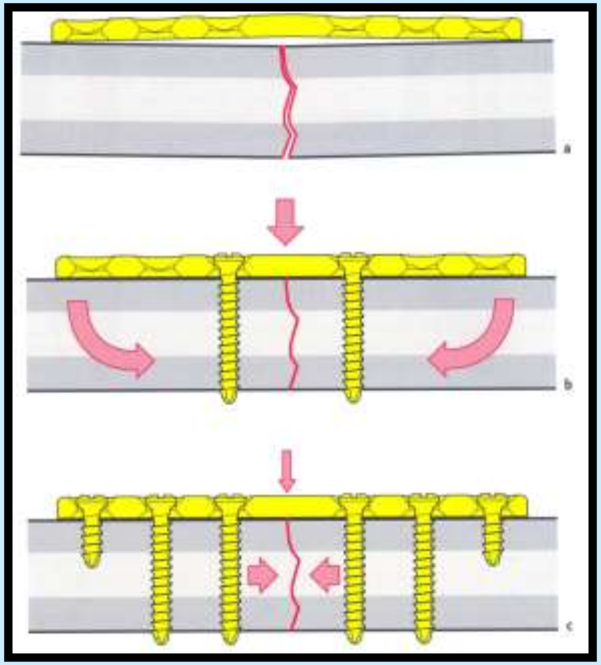
- Luhr 1977
- Two types of screws are used :
  - Compression screw
  - Static or passive screw
- Each compression hole will produce 0.8mm of bone movement – both sides of fracture, a total 1.6 mm of bone movement may be achieved.
- Often less than 1.6mm of compression is necessary to avoid lingual distraction of the fracture segments, stripping of the screws or splintering of the bone margins

Spherical gliding principle



Application of DCP :

1st Step : Pretension across the fracture is achieved with the use of bone forceps.



-Maximizes friction and stability

-May facilitate anatomic reduction

2nd Step : Adaptation of plate –

if not adapted properly will cause

distraction and malposition of

segments, poor anatomical reduction,

malocclusion or TMJ problems.

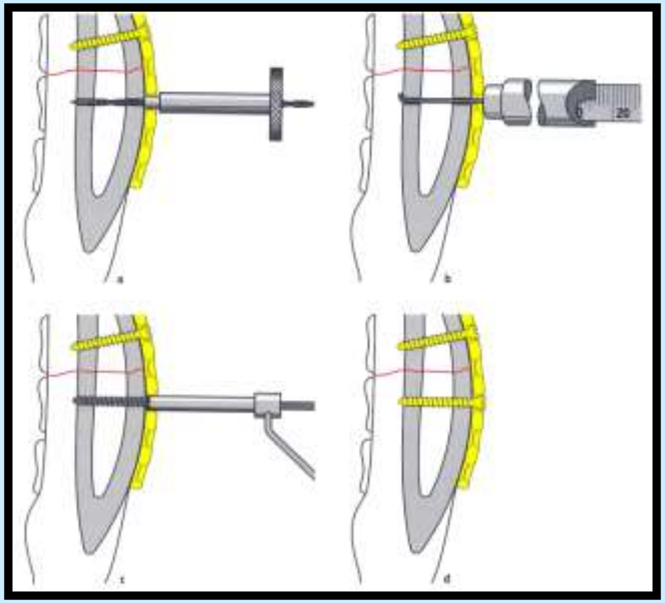
3rd Step : Holes for screws made with appropriate sized drill.

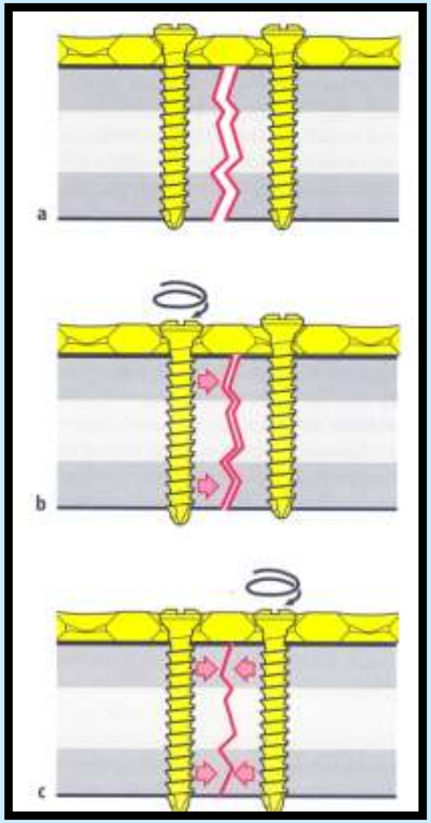
Screws are biocortical and are not self tapping.

Depth gauge used to establish proper screw length.

Appropriate tap is used to thread the entire depth of hole.

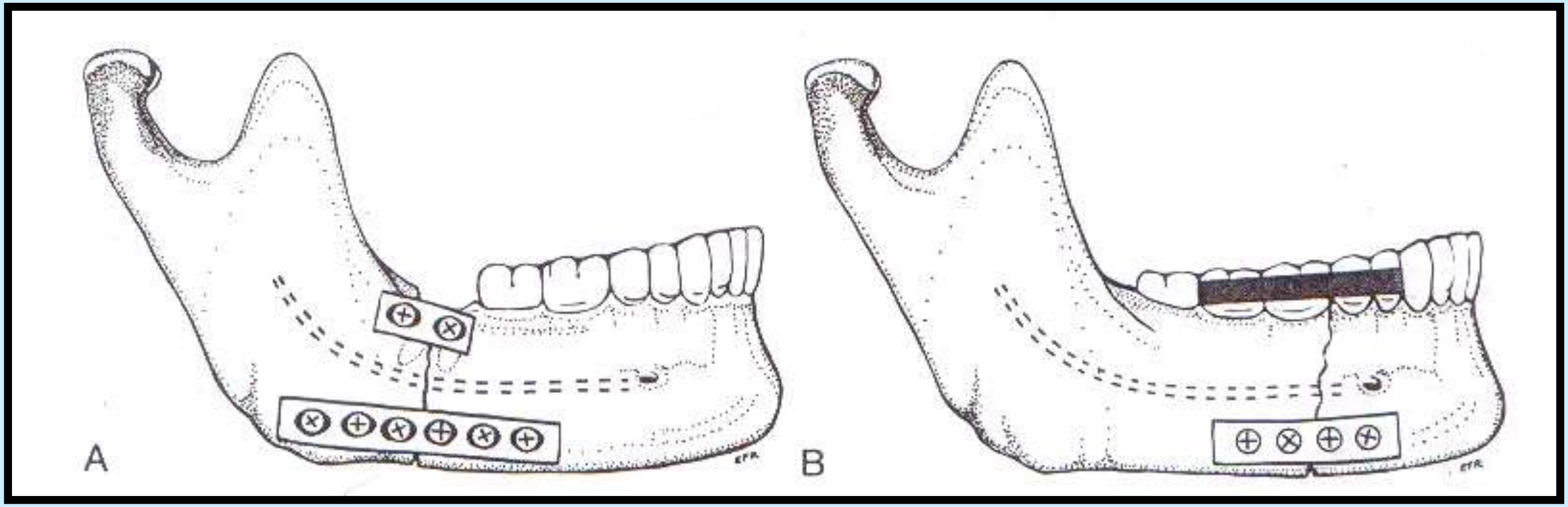
4th Step : Insertion of screws in specific sequence





Simple tension band : Prevents tensile forces from acting at the alveolus – minimizing distraction at the superior aspect of the fracture.

Axial compression occurs across the full width of the mandible preventing distraction at the occlusal border.

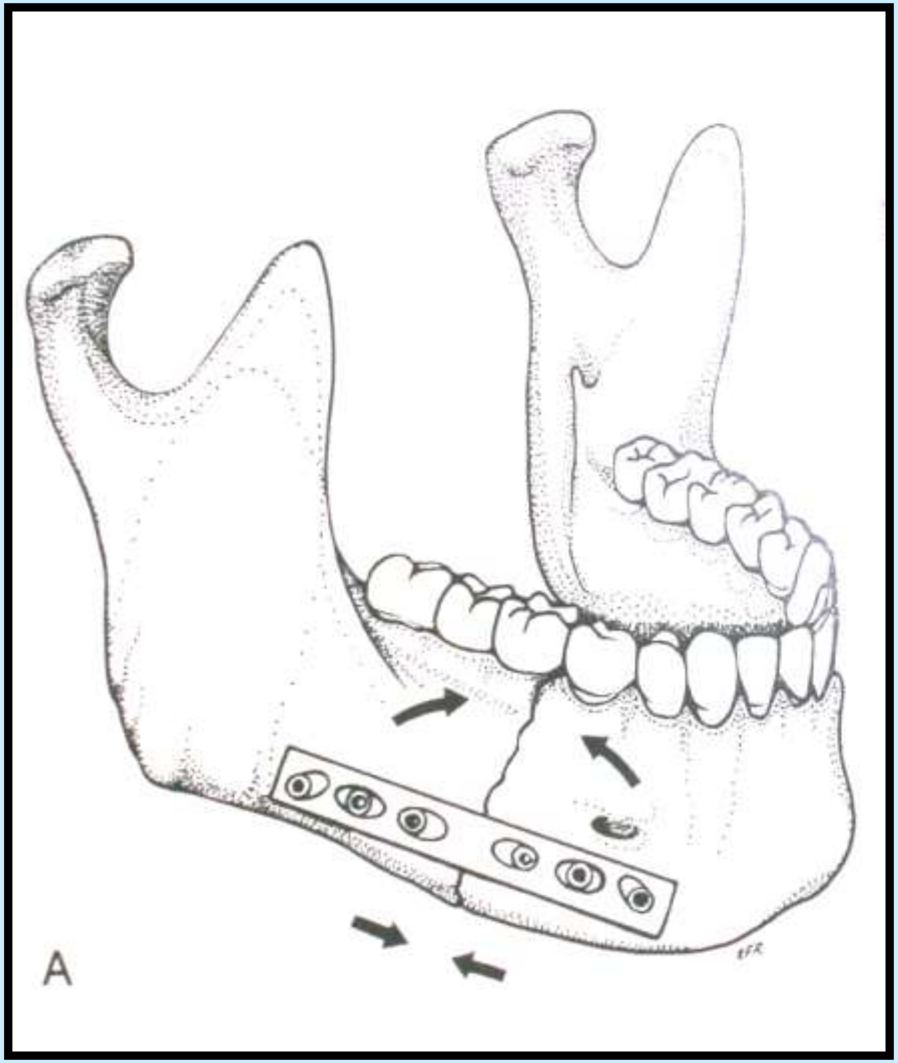


Eccentric Dynamic Compression Plates :

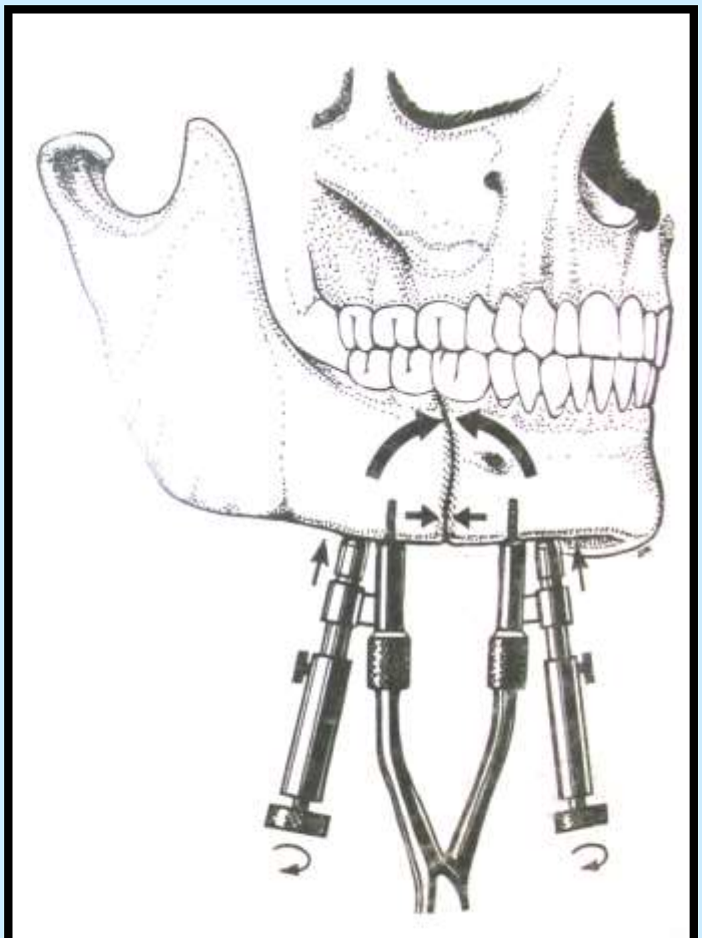
Schmoker, Niederdellman and Schilli - 1973 developed EDCP principle.

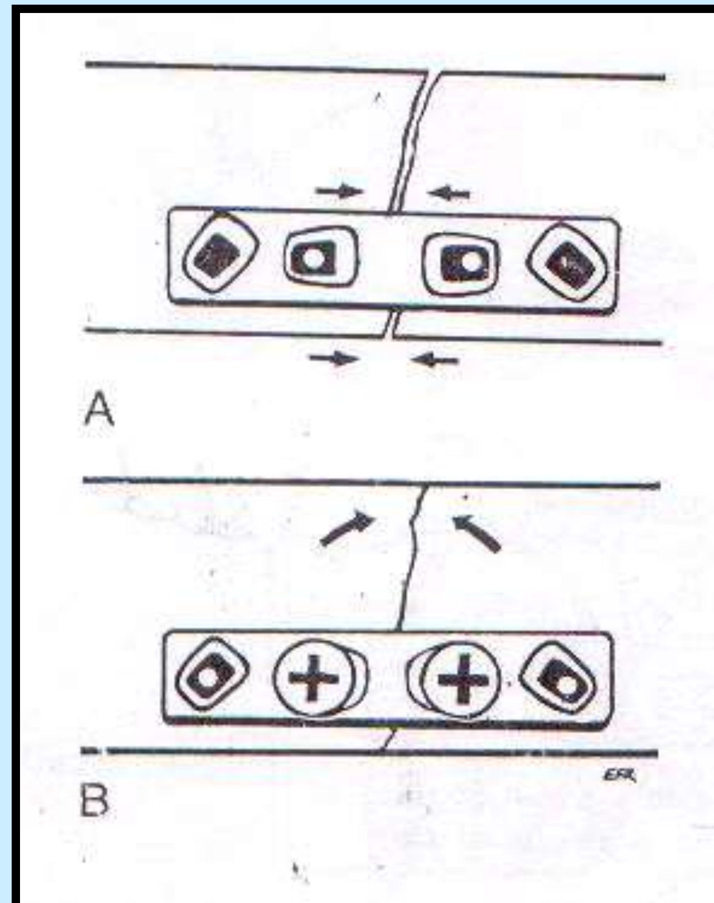
Goal - first establish longitudinal compression across the fracture at the inferior border and then to rotate the fragments around these screws to achieve additional compression at the level of the alveolus.

Inner holes as in DCP but outer holes oblique. Outerholes – produces rotational movement of the fracture segments with the inner screws acting as the axis of rotation – establishes compression at the superior border of the mandible.



Use - Situations where DCP and tension band cannot be applied because of anatomic constraints such as presence of an impacted third molar, edentulous mandible or avulsion of bone from the fracture.





Fixation osteosynthesis

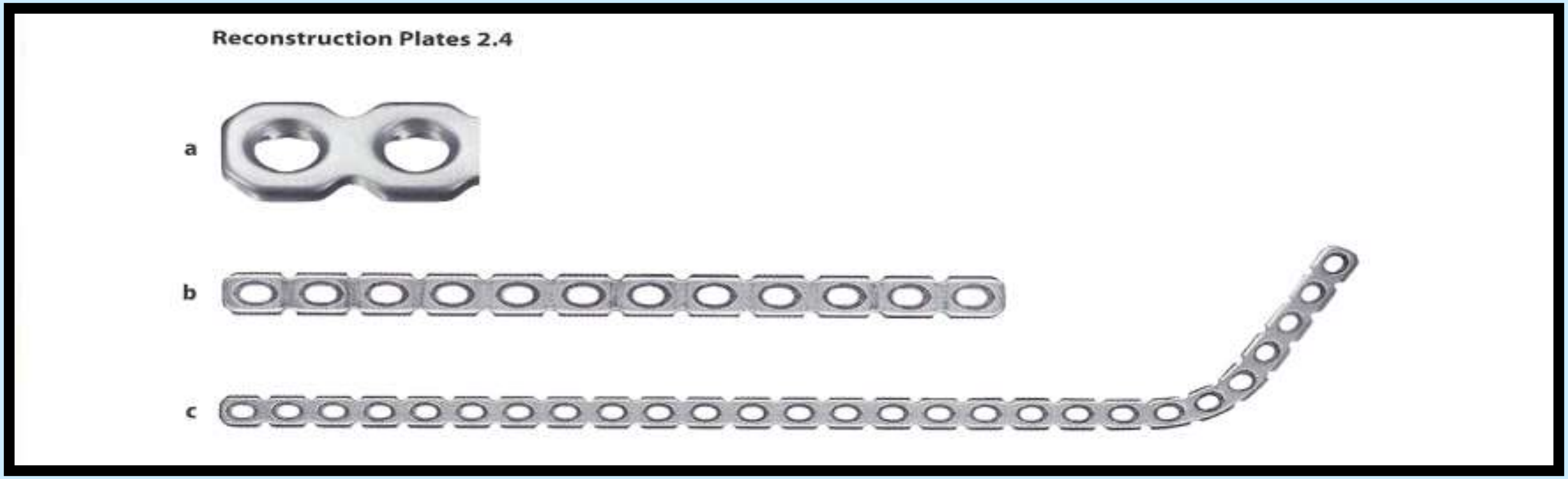
Indications

1. Severely oblique fracture
2. Communited fracture
3. Fracture with bone loss
4. Fracture of non atrophic edentulous mandible
5. Patient with questionable post op compliance

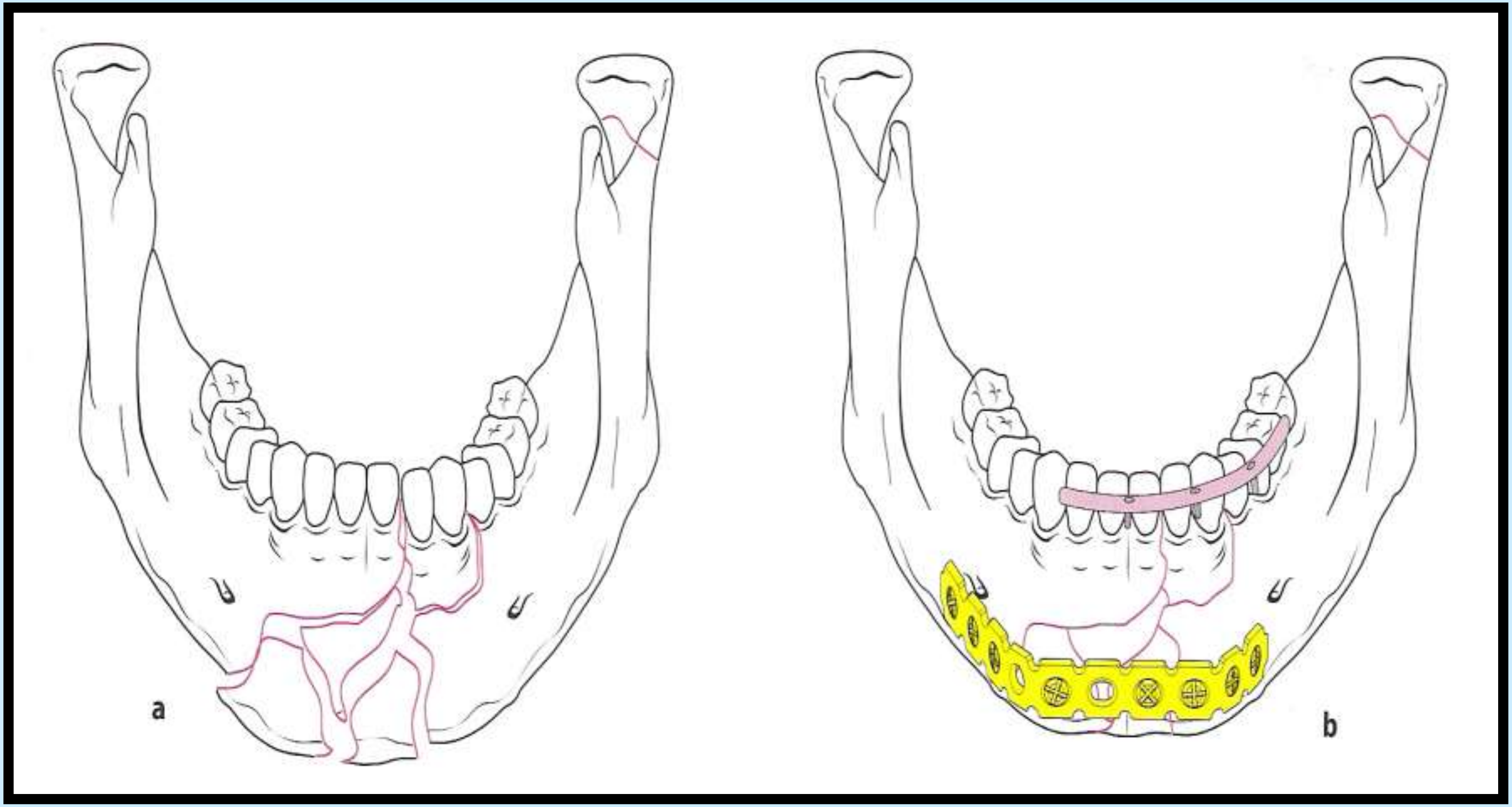
1. RECONSTRUCTION PLATES :

Indications :

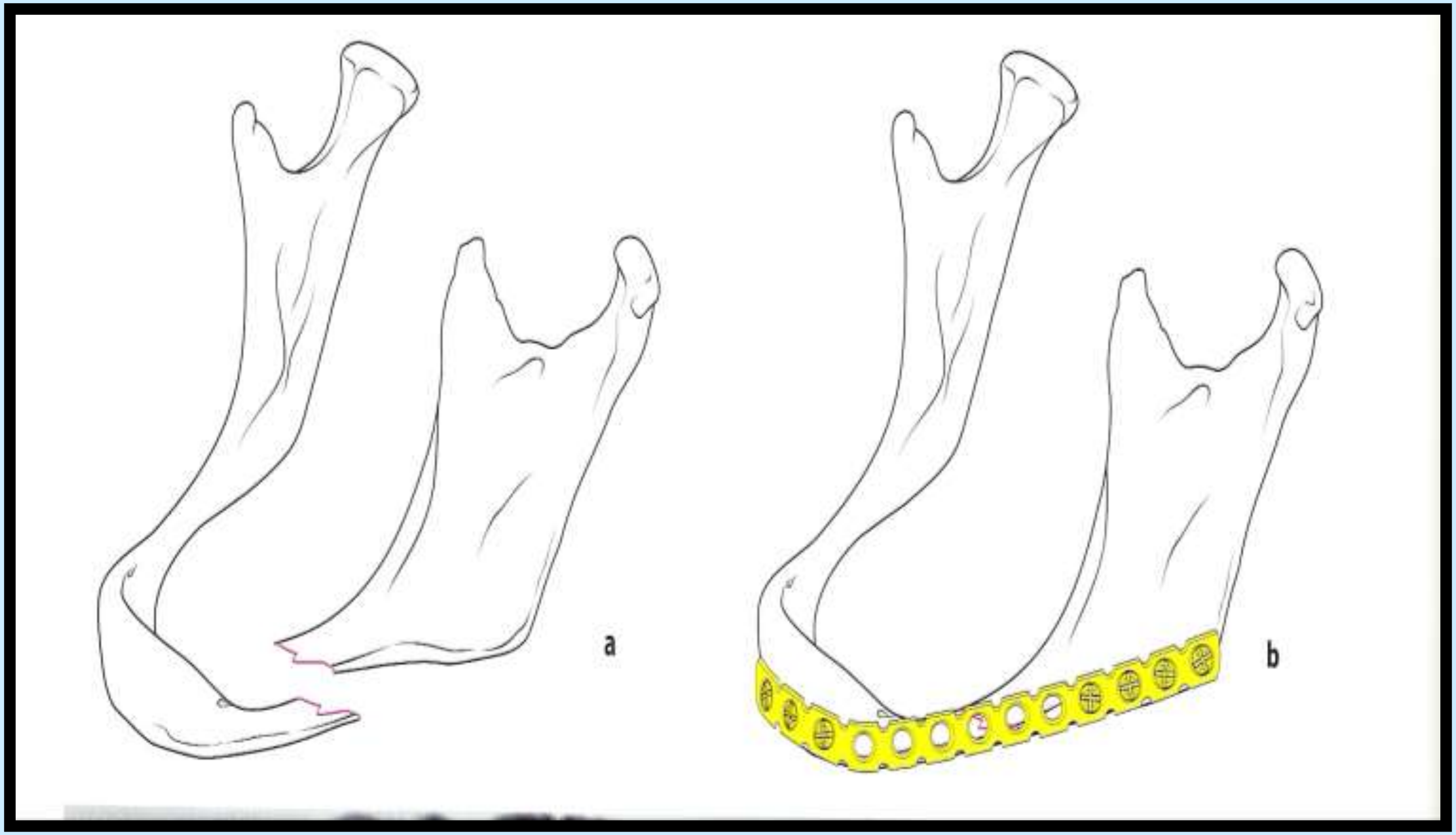
- For severely oblique fractures
- Comminuted fractures
- Fractures with bone loss
- Non atrophic edentulous mandible



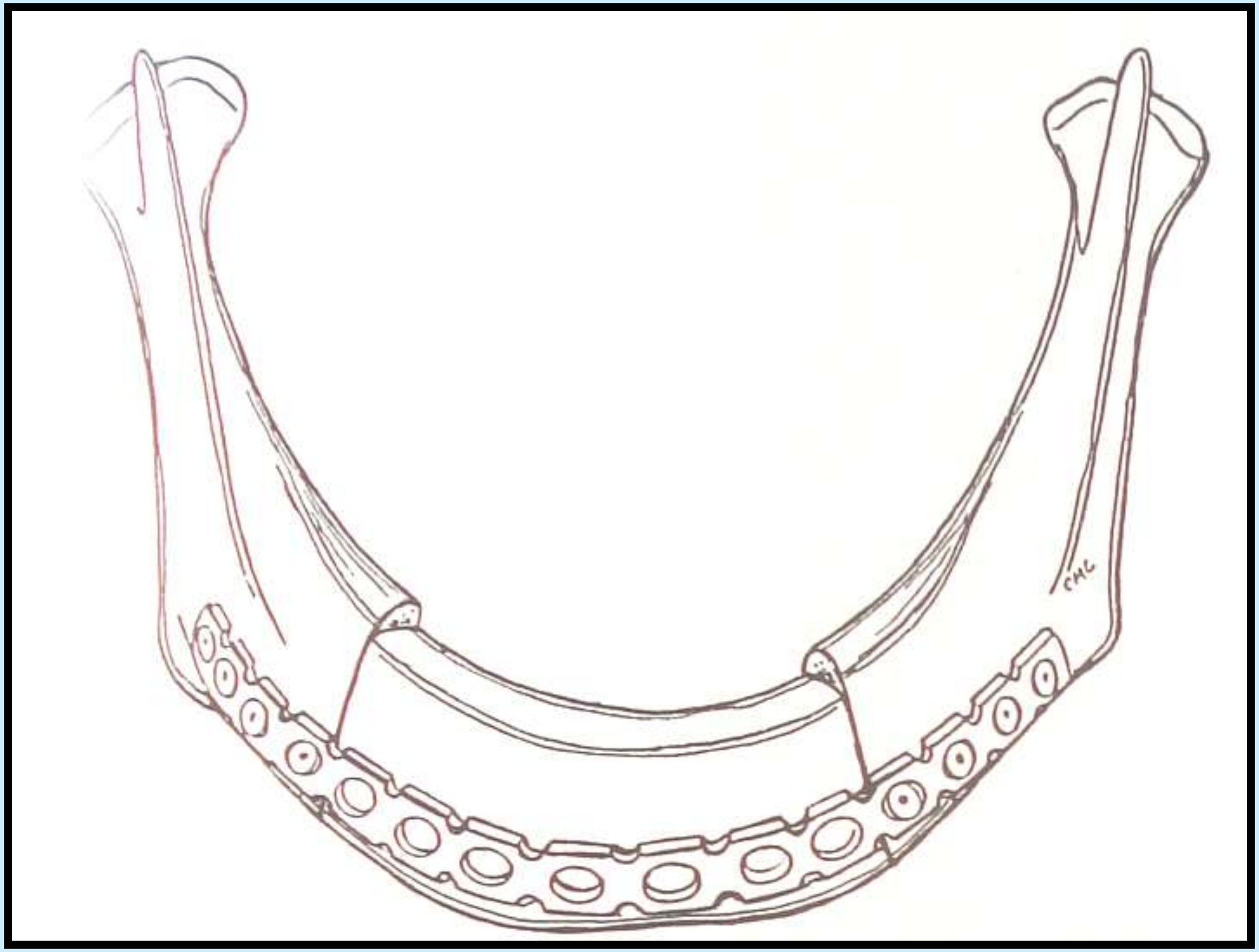
Fixation of communited fracture



Fixation of edentulous mandible



Fixation of graft



Advantages

- Provides small amount of compression
- At least 3 screws be placed in each of the fractured segments and if an osseous gap is being bridged, at least 4 screws to be placed in each segment.
- Can be controlled in three dimensions

Disadvantages

Screw loosening → mobility of the plate → instability of the bone segments → infections → non union/malunion.

2. THORP – Titanium Hollow Screw Osseointegrated Reconstruction Plate

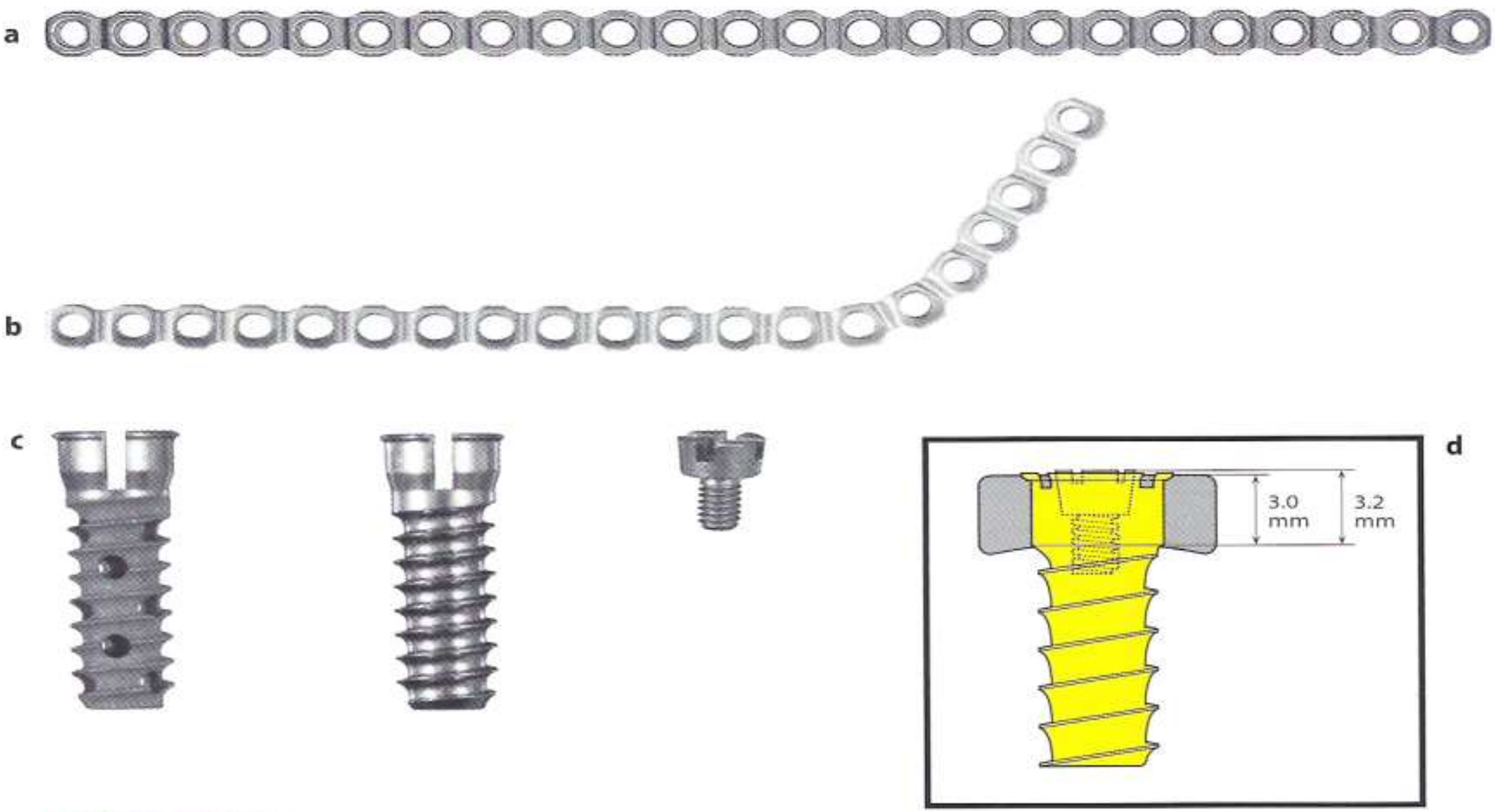
Raveh - developed THORP

The design of this system provides stability without applying pressure to the underlying bone. This system was designed with screws that will not become loose over long periods & can provide adequate long-term functional stability.

Indications :

- Bridge large defects
- Stabilize bone grafts especially in patients with compromised bone and soft tissue (following radiation therapy).

THORP Reconstruction Plates 4.0



THORP

Fig. 1.27 a–d

Titanium hollow reconstruction plate (THORP). Plate thickness 3.0 mm. Screws with special heads can be locked in plate hole with special locking screws.

a Straight plate.
b Angulated plate left side.
c Hollow and solid 4.0 screws with additional locking screw.
d Plate/screw profile of THORP system. Plate with special 4.0 screw with locking screw in place.

Principle :

•Uses friction created between the screw and the hole in the plate to stabilize the plate and fracture.

•THORP is made from titanium IMI-160 which has great strength resistant to fatigue and biocompatibility.

Advantages :

•Screws are osseointegrated and become more stable over time.

•Avoids pressure to the bone

•Eliminates micro movements

Disadvantages :

•Difficult to use

•More costly

3.Locking plates :

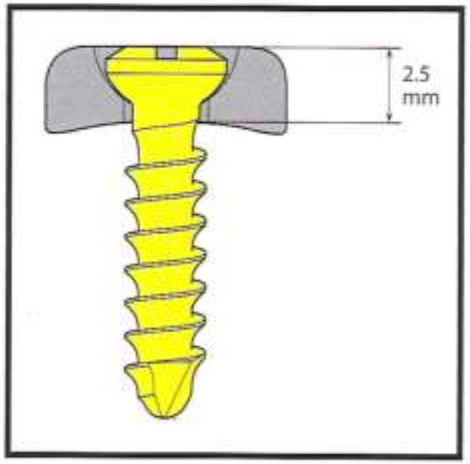
- Designed with threaded holes through which screws pass.
- Two separate points of fixation for each screw :- into bone and into threads of each screw hole of plate

Advantages

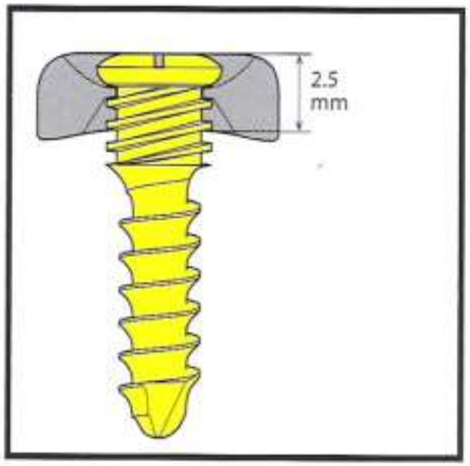
1. Screw locks to plate independent of bone & therefore plate provides fracture stability without requiring direct contact to bone.
2. As the plate is not compressed against the bone , more periosteum remains viable to aid in fracture healing.
3. If the screw lose it's purchage in the bone , it remains immobile because of it's fixation to the plate.
4. Very few complication rates. (7%).

d

e



f



g

Fig. 1.25 a–g

Reconstruction plates 2.4 are much stronger than universal fracture plates. Plate thickness 2.5 mm. These are used for temporary load bearing situations.

Note: Plates cannot be used as permanent load-bearing implants.

If supplied with threaded holes, they can be used either in the regular manner with the regular 2.4 screw or as a locking system together with the special locking 2.4/3.0 screws.

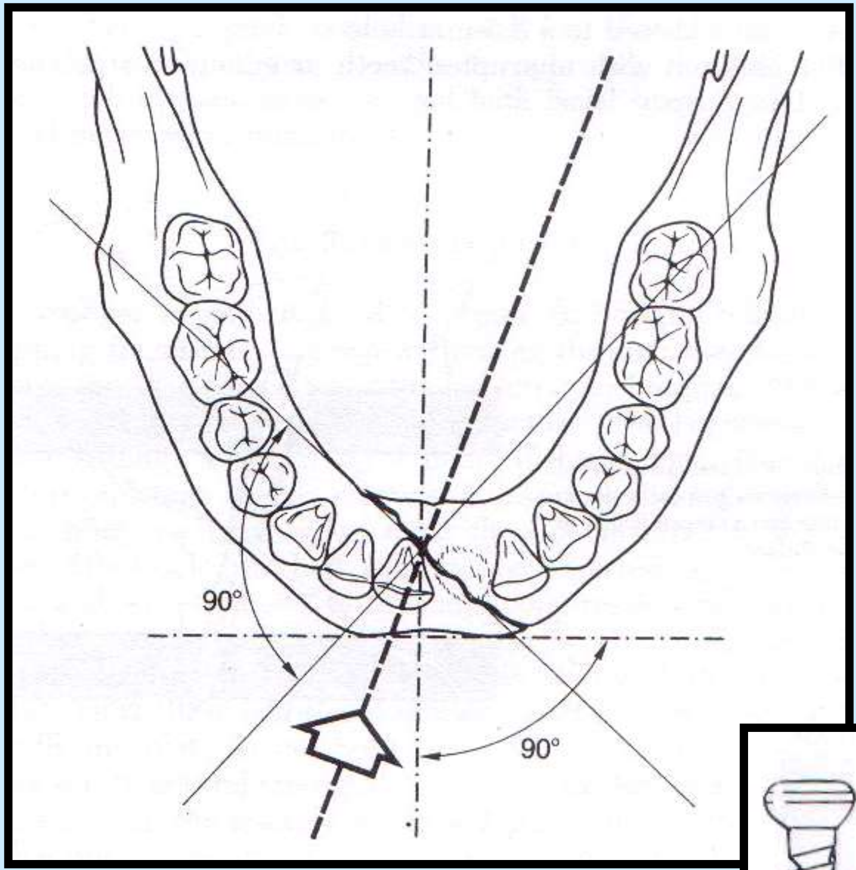
a Oval-shaped plate holes with thread.
b Straight plate.
c Prebent angulated reconstruction plate for the right or left side (left side shown).
d 2.4 MF cortical screw for reconstruction plates.
e UniLOCK screw with additional thread for plate hole and threaded inset for plate hole protection during bending.
f Plate/screw profile of reconstruction plate without thread and regular 2.4 screw.
g Plate/screw profile of UniLOCK system. Reconstruction plate with threaded hole and special 2.4 locking srew.

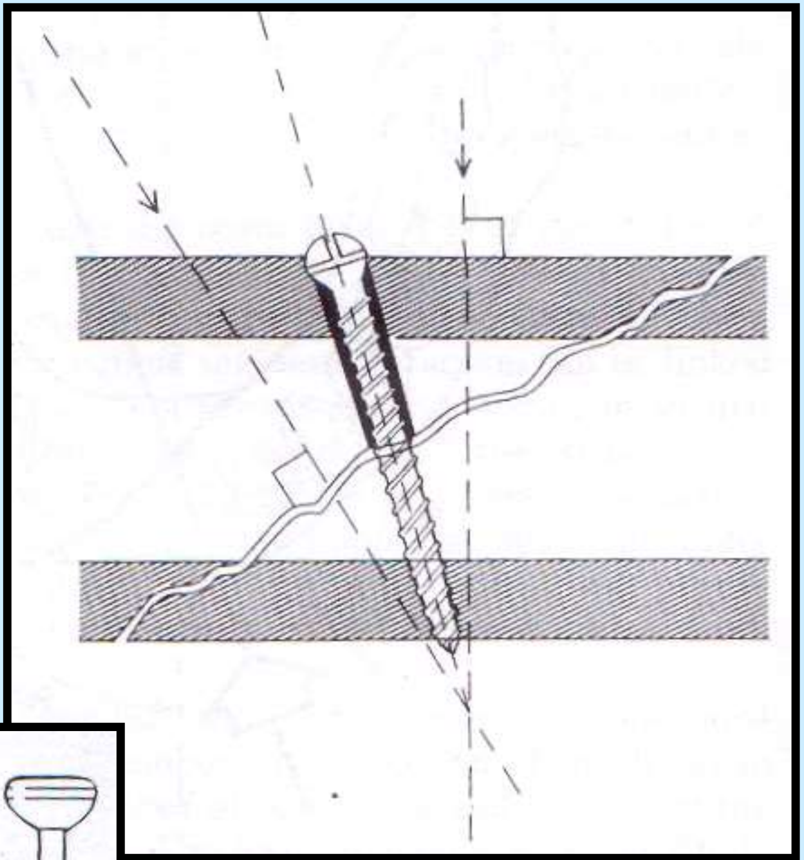
LAG SCREWS OSTEOSYNTHESIS :

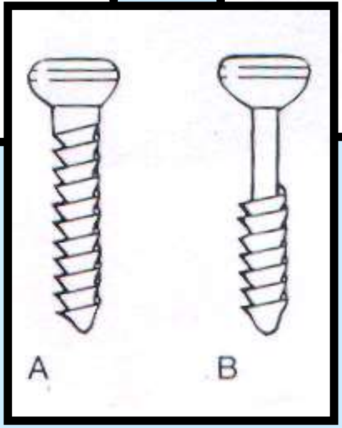
Advantages

1. Donot require plate adaptation, making them faster method of fixation
2. Fixation is secured with two screws, less hardware
3. Can be used alone if fracture is sufficiently oblique.
4. Offer most rigidity of all fixation technique

Principle of application of lag screw







Application of lag screw

A. Drilling of outer cortex with diameter drill

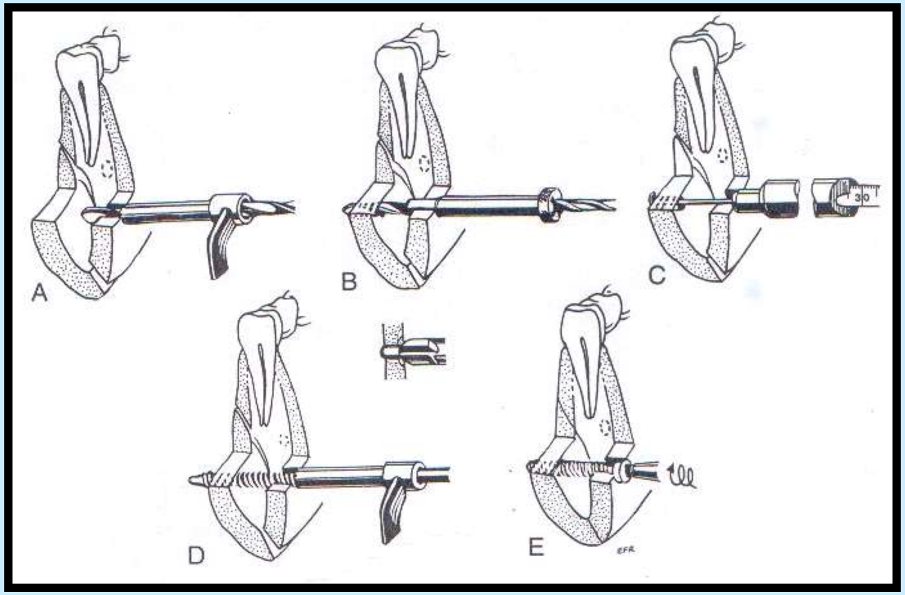
B. Inner cortex drilled with smaller diameter drill with drill guide that fits in outer cortex hole.

Outer cortex is countersunk with special drill

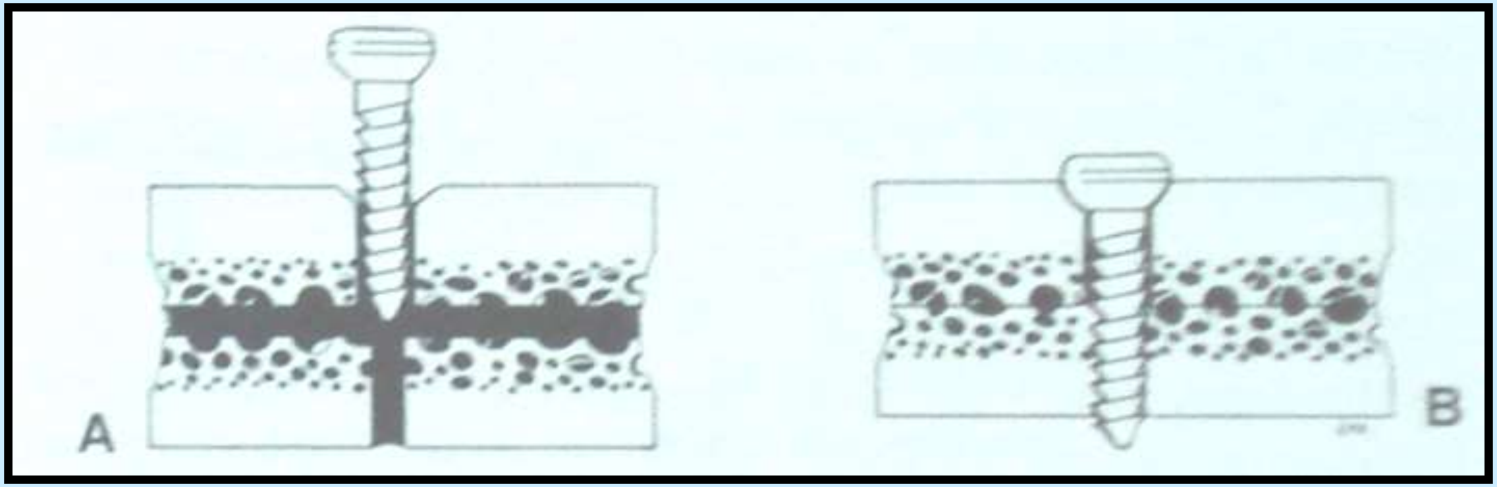
C. Depth gauge – to determine length of scew

D. Inner cortex tapped

E. Screw placed causing compression across fracture

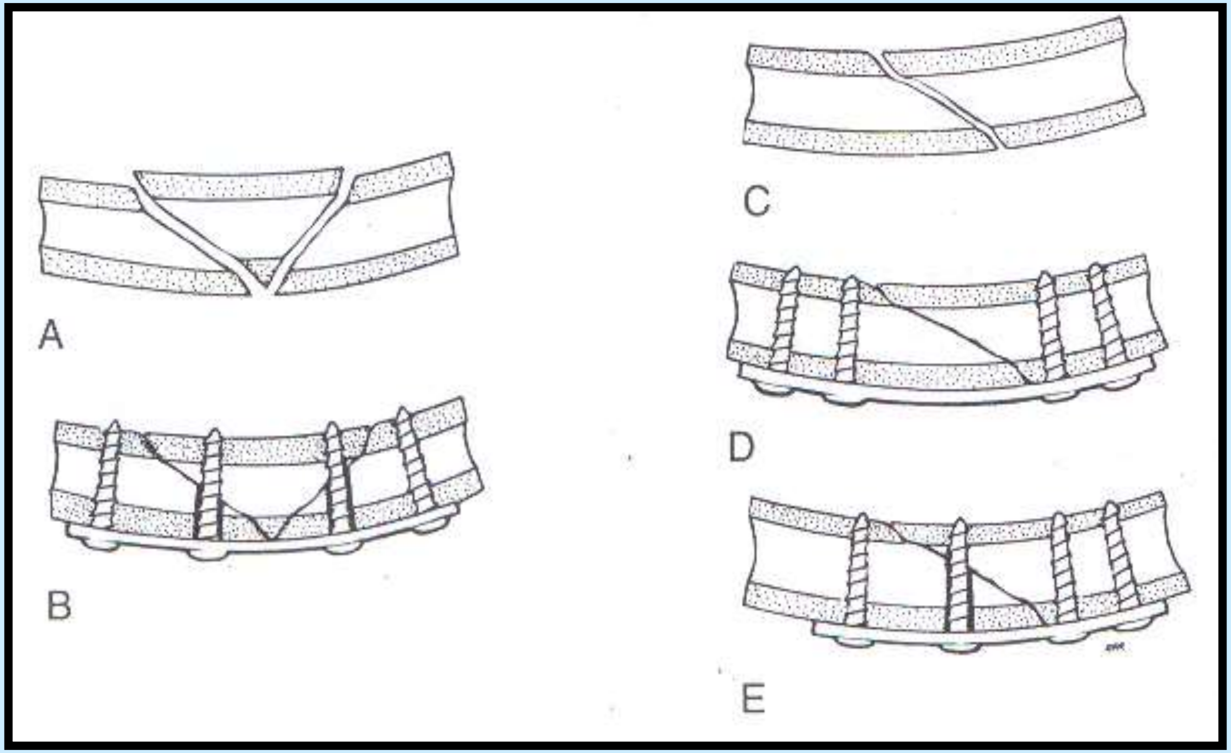


Use of conventional screw as lag screw



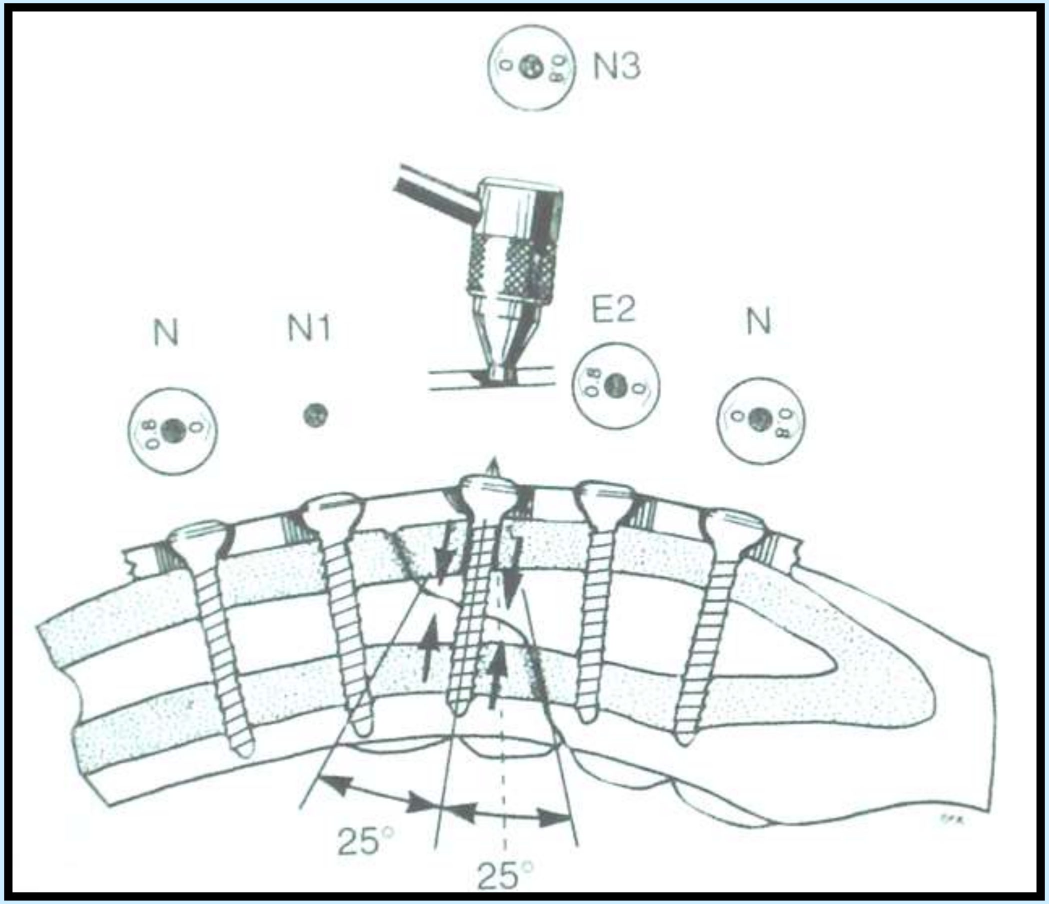
1. Gliding hole prepared in outer cortex with a diameter equal to thread diameter of screw
2. Traction hole prepared in inner cortex with help of drill guide
3. Traction hole is tapped
4. Countersinking of outer cortex
5. Screw insertion to achieve compression of fracture segments

Use of lag screw with non compression plates



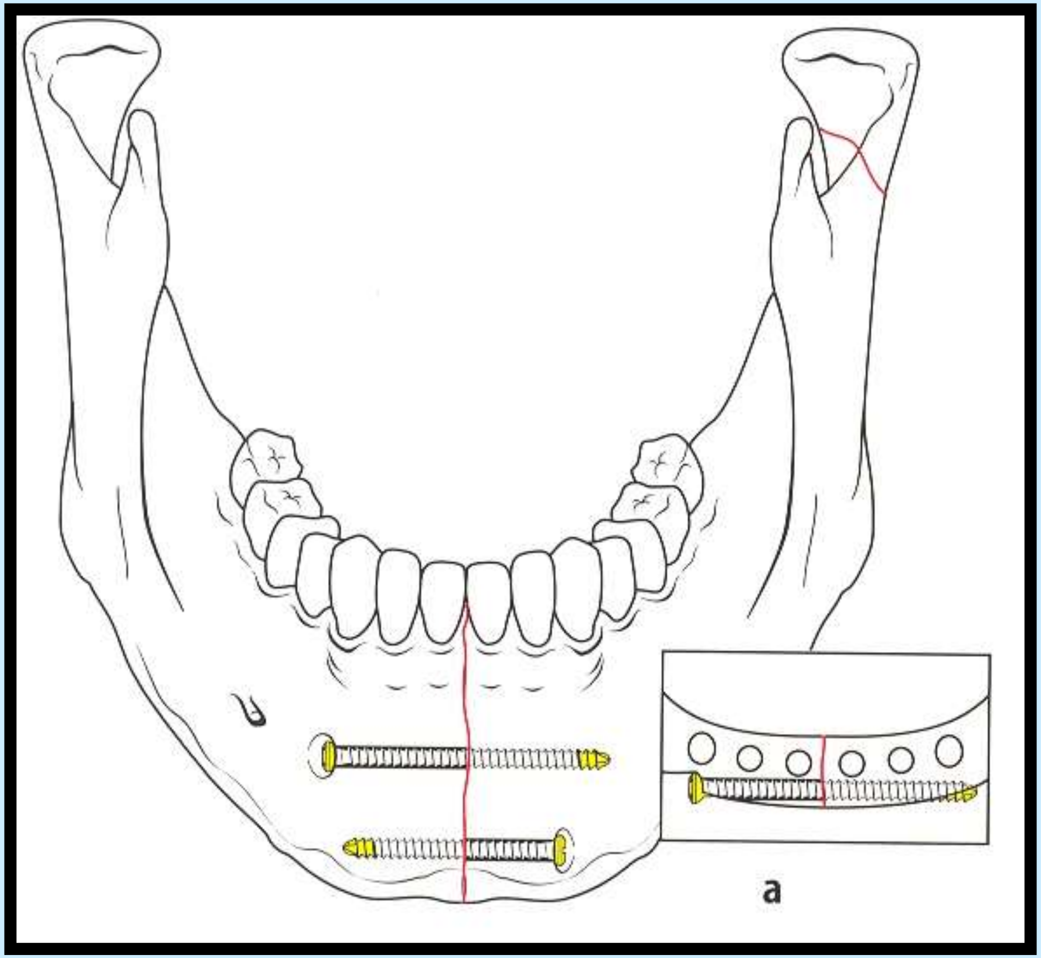
Use of lag screw with compression plates

1. Screw N1 placed in neutral fashion
2. Screw E2 placed in compression
3. Lag screw placed
4. Two outer screw placed in neutral position

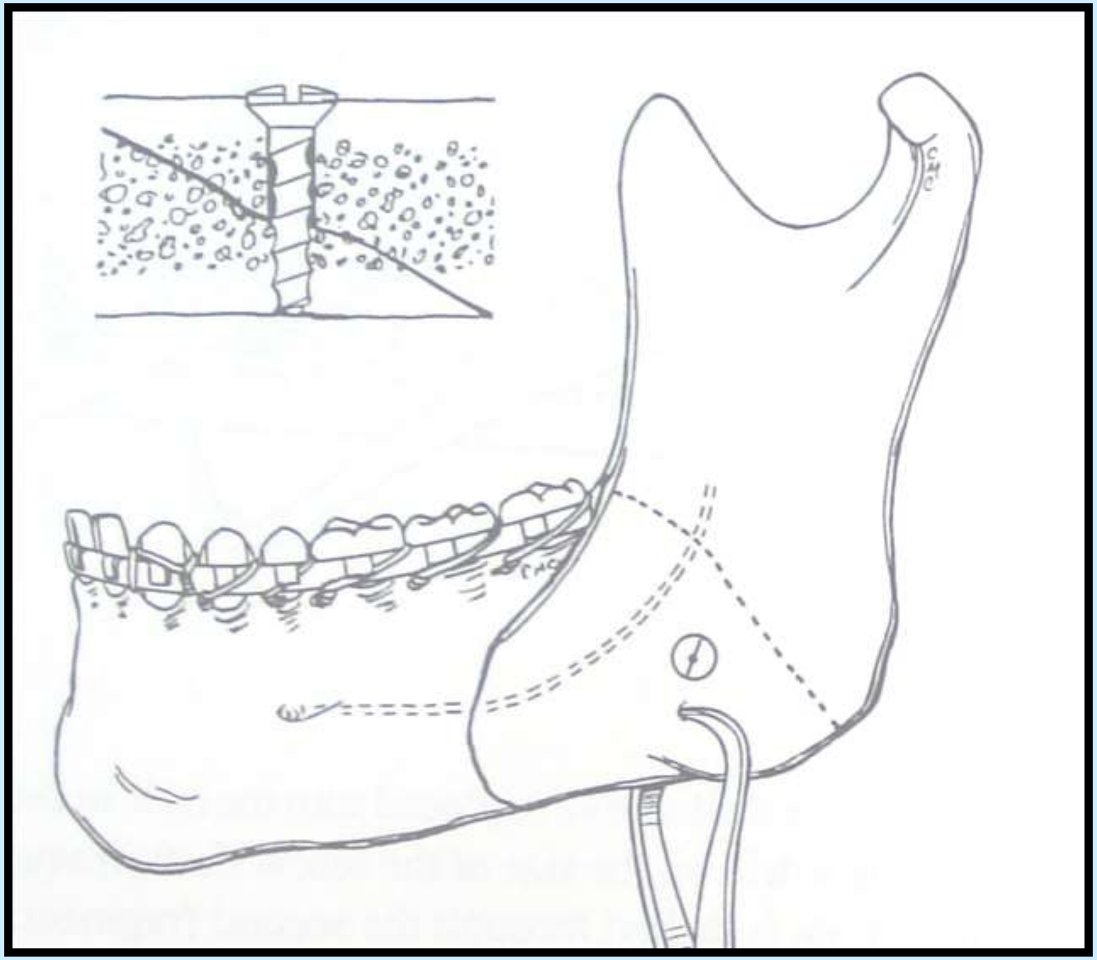


Symphysis fracture

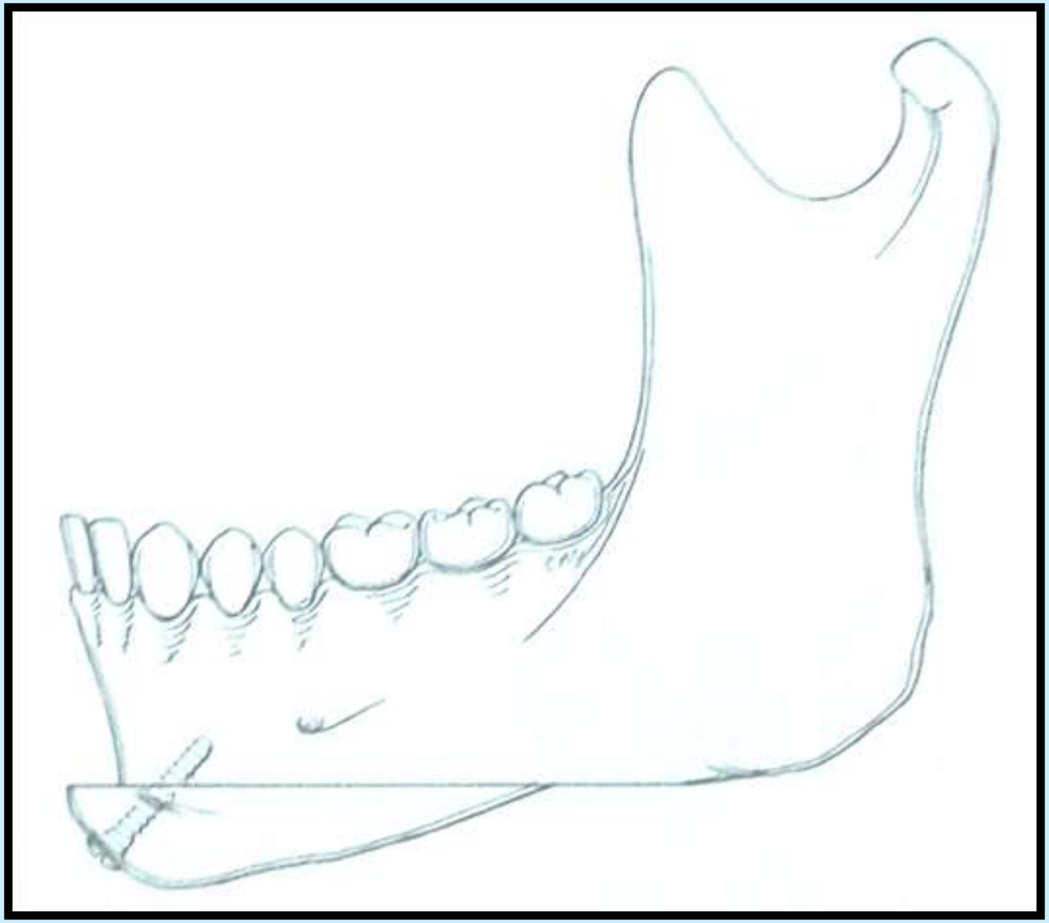
Usually 2 lag screws provide adequate fixation

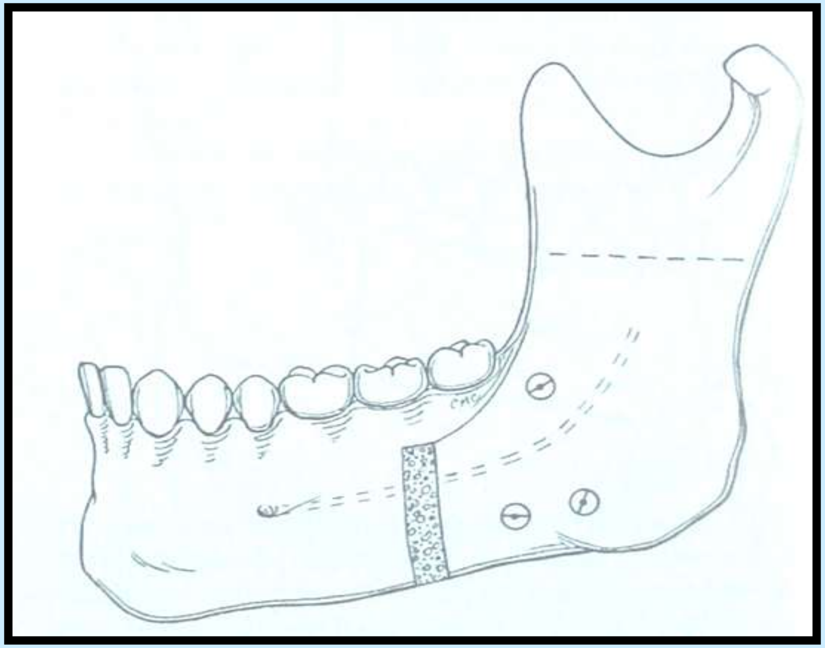


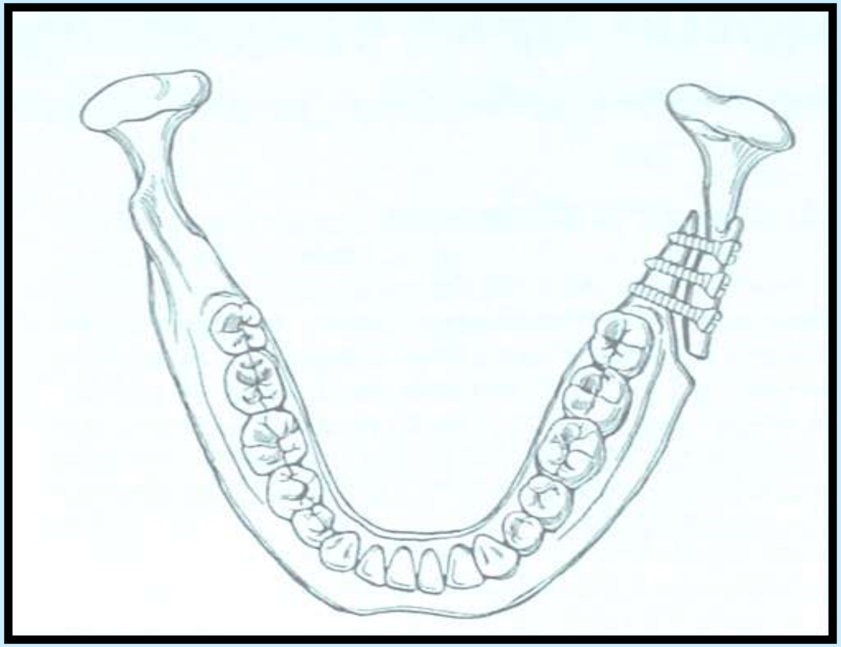
Overriding fracture



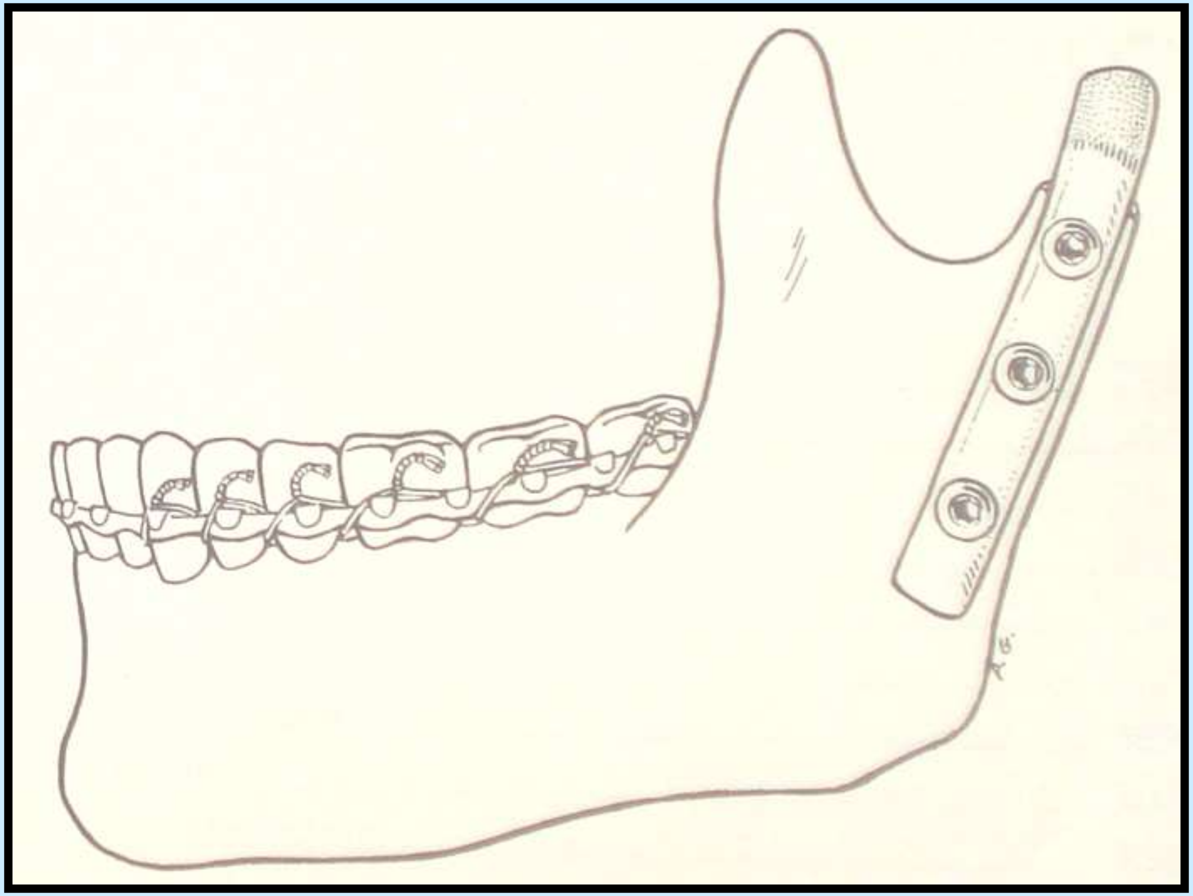
Use of lag screw in orthognathic surgery







Fixation of graft



MINI PLATE OSTEOSYNTHESIS :

Michelet and colleagues – 1960

- Original goal of miniplate osteosynthesis – stable mandibular fracture reduction without requiring interfragmentary compression or MMF.
- Miniplates achieve this goal by lateralizing undesirable tensile forces while retaining favorable compressive forces during function.

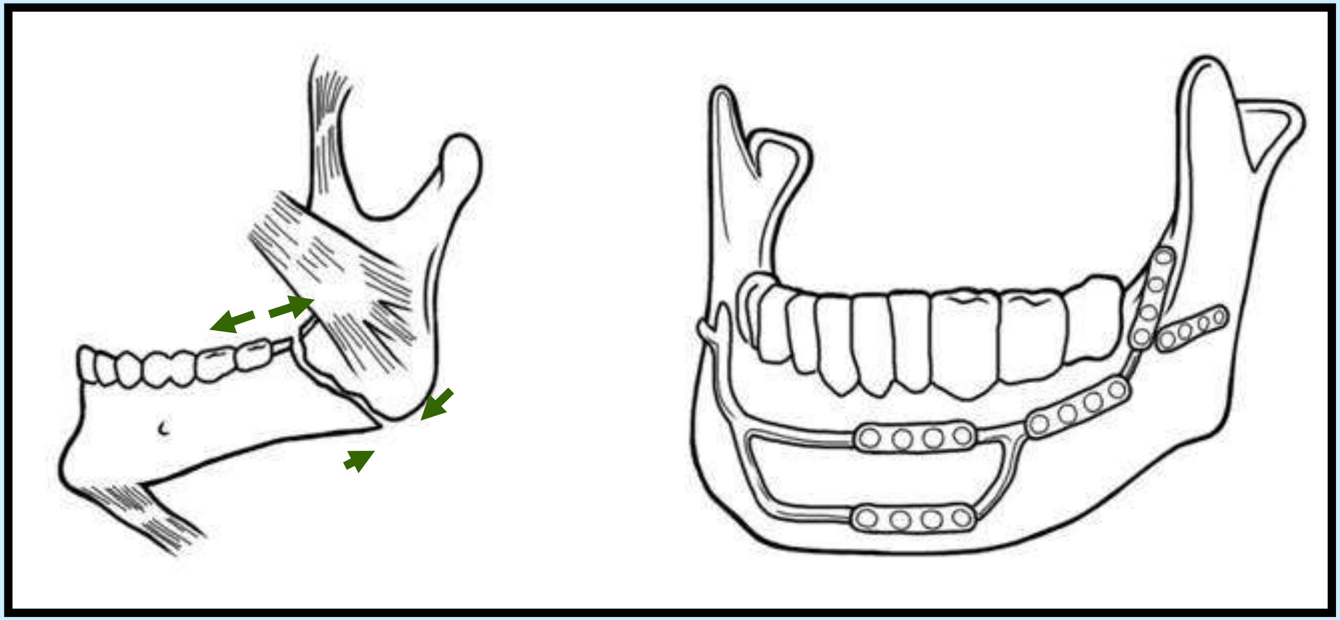
Advantages

- Smaller incisions and less soft tissue dissection
- Can be easily placed intraorally
- Less palpable
- Smaller size of miniplate may decrease the stress shielding seen following rigid fixation.
- Monocortical screws – can be placed adjacent to tooth roots

Disadvantages

- Smaller size – not as rigid as standard mandibular fracture plates →lead to torsional movements under functional loading → infection or nonunion or both.
- Reduced function is recommended after fracture fixation – Soft diet for 3-6 weeks or 1 to 2 weeks of MMF.

Plate Positioning



Champy's ideal osteosynthesis line

For mandibular body fracture fixation, one plate is sufficient to provide firm support and to offset the tensile forces.

In front of the mental foramena (premolars), 2 plates are necessary to resist the torsional forces.

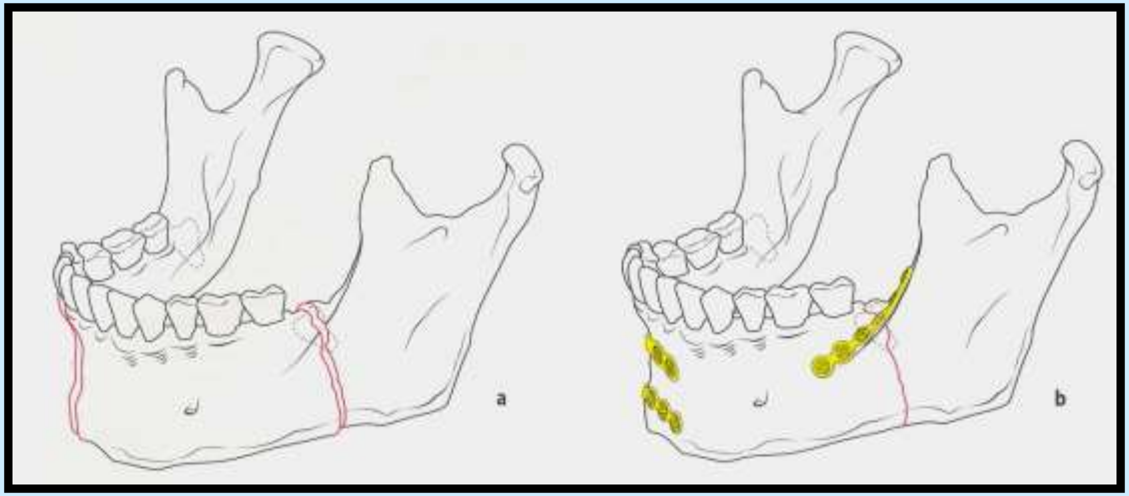
Clinical applications :

Mandibular angle fractures :

plate – superolateral aspect of the mandible with rotational band to follow the contour of the external oblique ridge.

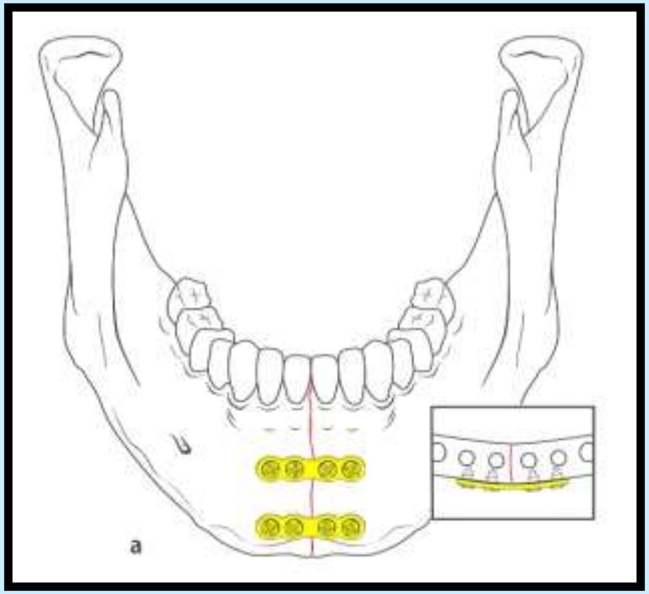
Two screw holes – each fracture segment

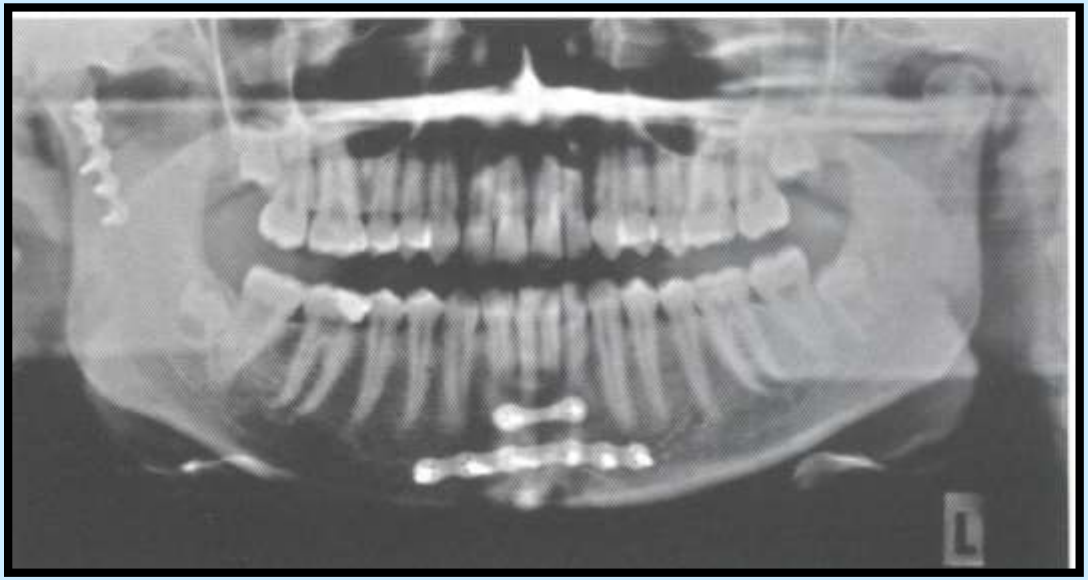
Shetty and Caputo – torsion of the proximal and distal fracture segments was found to occur during loading and gap at the inferior aspect of the mandible – advised second plate at inferior border of mandible.



Mandibular symphyseal and parasymphyseal fractures :

Torsional forces generated during function – two parallel plates are placed to resist interfragmentary movement.

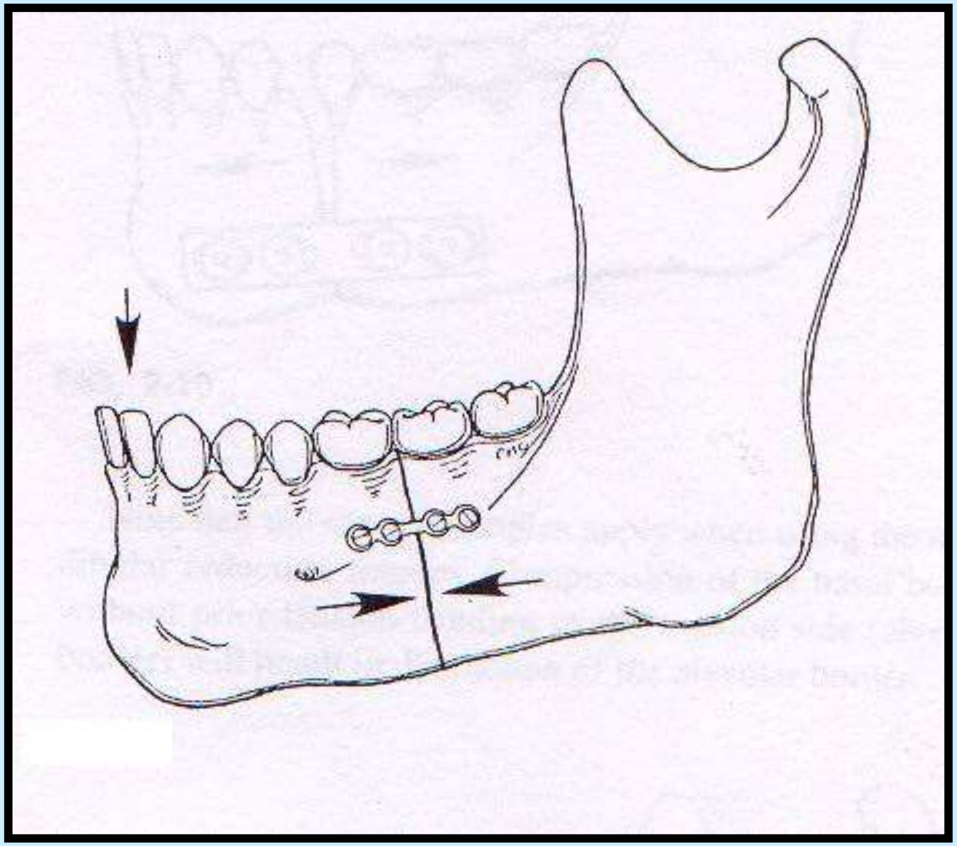




Mandibular body fractures :

Non displaced or minimally displaced fractures provided that fracture is not severely comminuted.

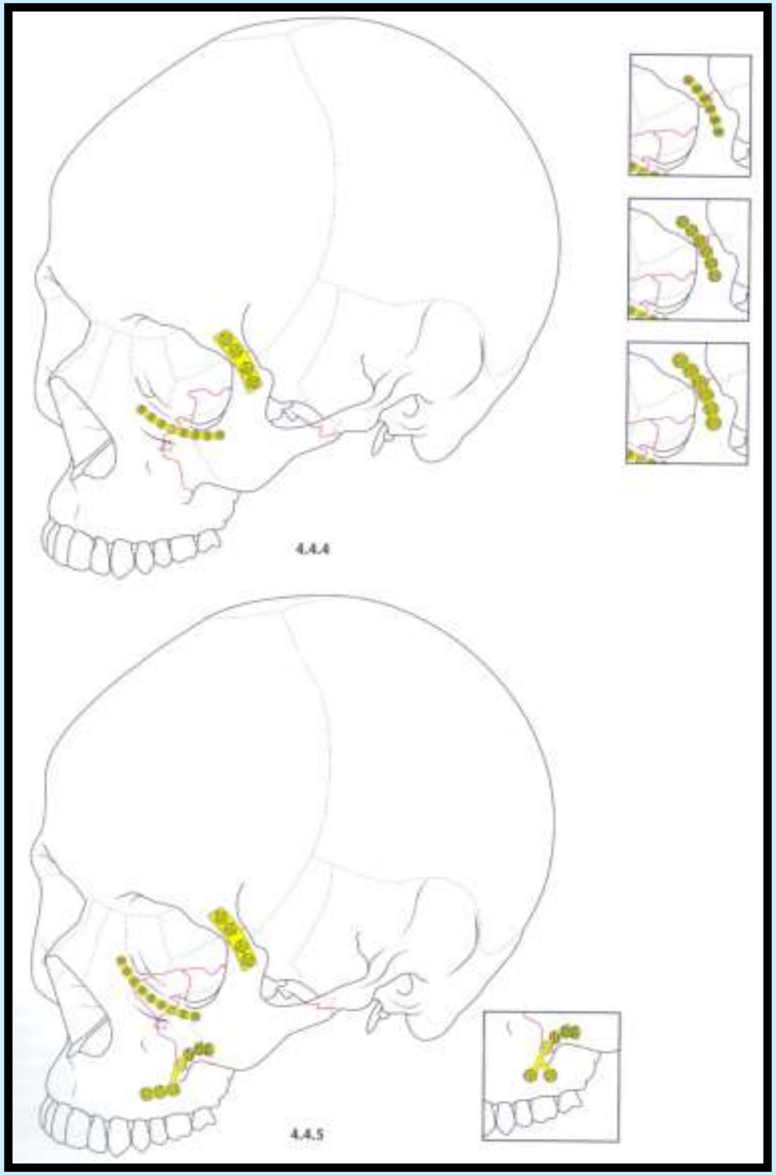
Plate – Juxta alveolar region, just above the inferior alveolar canal



Midface fractures :

Advantages

- Rarely palpable
- Cosmetically acceptable
- Allow precise anatomic reduction
- Stable fixation of bone grafts.
- Facilitate reconstruction of facial bones in complex communited fracture

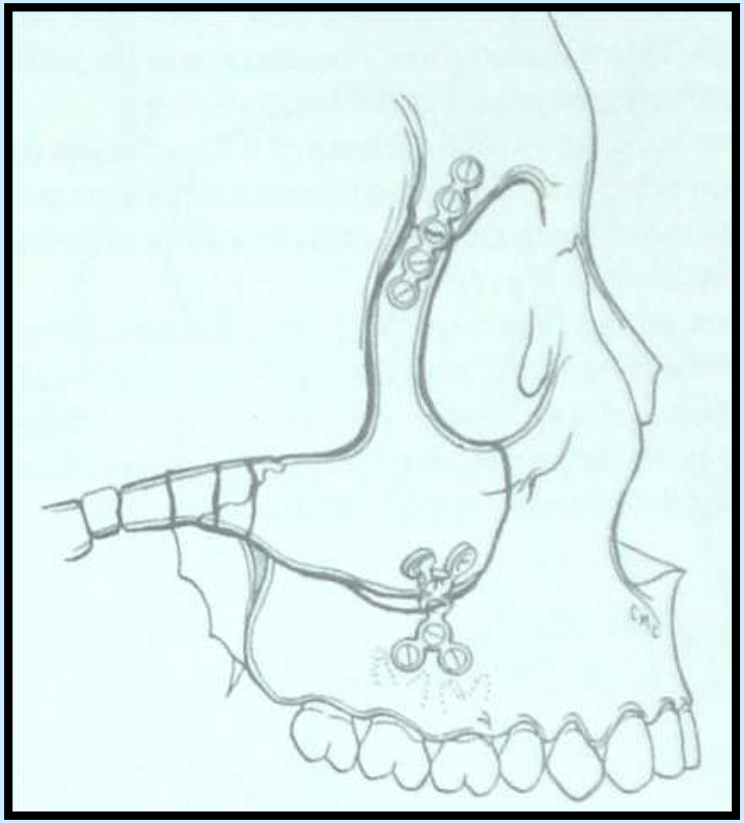


- Weak forces on midfacial bones – plate placement determined by line of fracture rather than lines of stress.
- Whenever possible plate should be aligned along the long axis of the facial buttresses to provide thicker bone for screw retention.

ZMC fracture

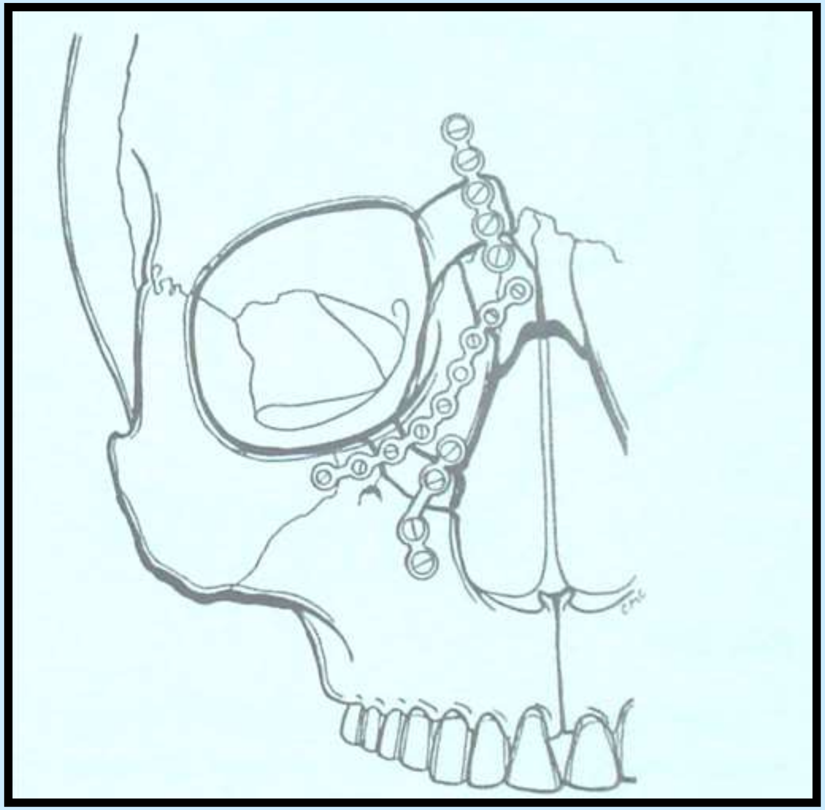
- F – Z region & zygomaticomaxillary region fixation usually sufficient

If necessary infraorbital rim fixation done. All 3 fixation also called tripoid fixation.



Nasal fracture

- Nasofronatal fixation necessary
- Infraorbital rim can also be fixed along with nasal bone along frontomaxillary buttress



NOE fracture

- A single plate across dorsum of nose
- In severe cases transnasal wiring done with nasal plate fixation.

Le Fort I fracture

- Fixation at nasomaxillary & zygomaticomaxillary region

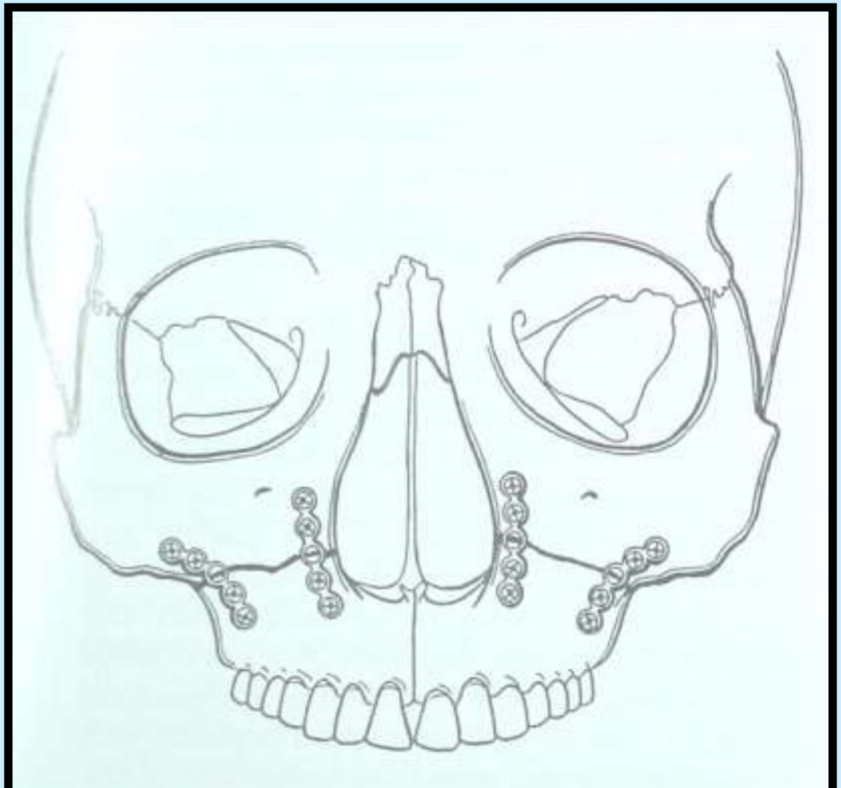


Figure 8.9. Isolated maxillary fracture repaired with adaptation plates along the zygomatic and nasoalveolar buttresses. Note: L-shaped plates are also applicable in these situations.

Le Fort II & III fracture

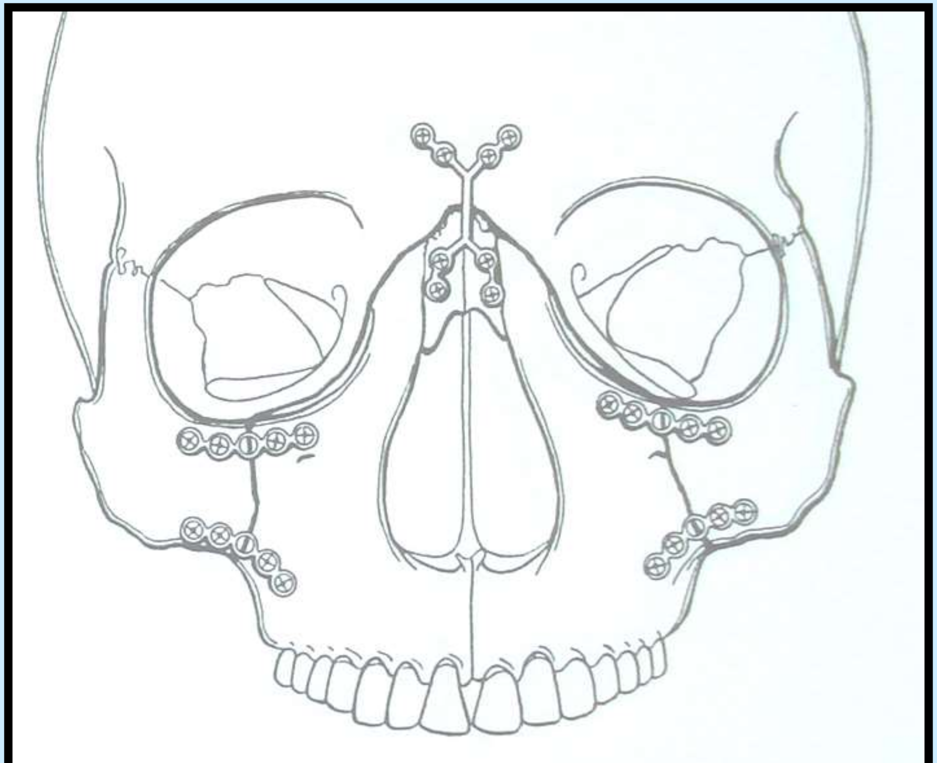


Figure 8.10. Pyramidal fracture with adaptation plates at the zygomatic buttress and infraorbital truss. Additional micro X-plate at nasofrontal suture. Note: L-shaped plates may be desirable at the zygomatic buttresses.

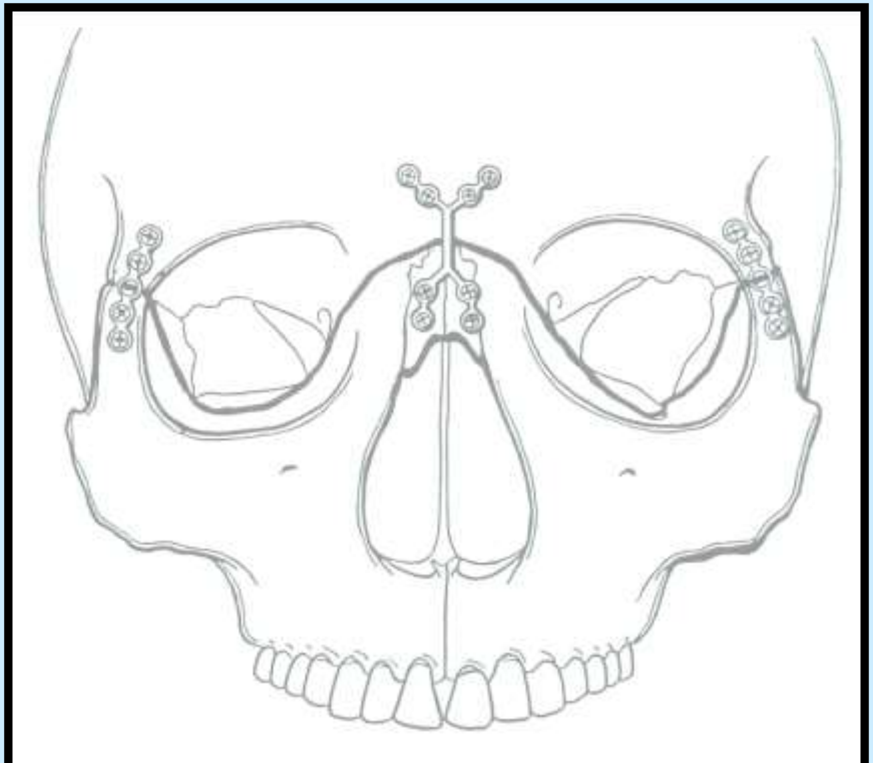


Figure 8.11. Craniofacial dysjunction with adaptation plates at the zygomaticofrontal suture to support the zygomatic buttress. Micro X-plate at nasofrontal suture.

TABLE II.2 *Typical forces and requirements (anatomical areas and fractures, as gross approximations)*

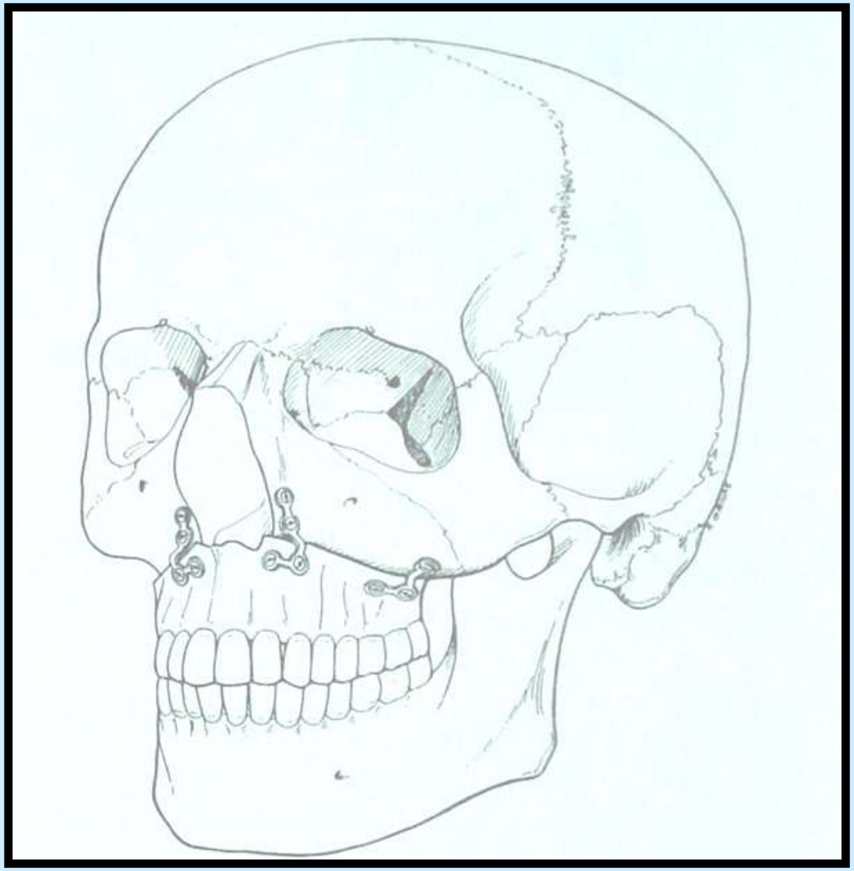
Area	Forces	Repair technique
Frontal/cranial	Minimal	Wires Microplates Three-dimensional microplates Miniplates
Zygomatic tripod (F-Z)(Z-M)	Moderate (rotational)	Minicompression plate Miniplate (multiple sites) Three-dimensional microplate (multiple sites)
Zygomatic arch	Moderate (masseteric pull)	Wires Microplates
Infraorbital rim	Minimal	Wires Microplates
Le Fort I, II buttresses	Moderate (compressive)	Miniplates Three-dimensional microplates (eight hole) Bone grafts with lag screws
Anterior maxilla	Minimal	Wires Microplates
Nose, nasoethmoid	Minimal	Wires Miniplates Microplates
Mandible	Maximal (torsional, distracting, compressive)	Miniplates Three-dimensional miniplates Compression plates Reconstruction plates (with utmost attention to biomechanical principles)

F, frontal; Z, zygomatic; M, maxilla.

Orthognathic surgery

Le Fort I osteotomy

- Plates adapted in stepwise fashion
- Plates – nasomaxillary & zygomatic buttress



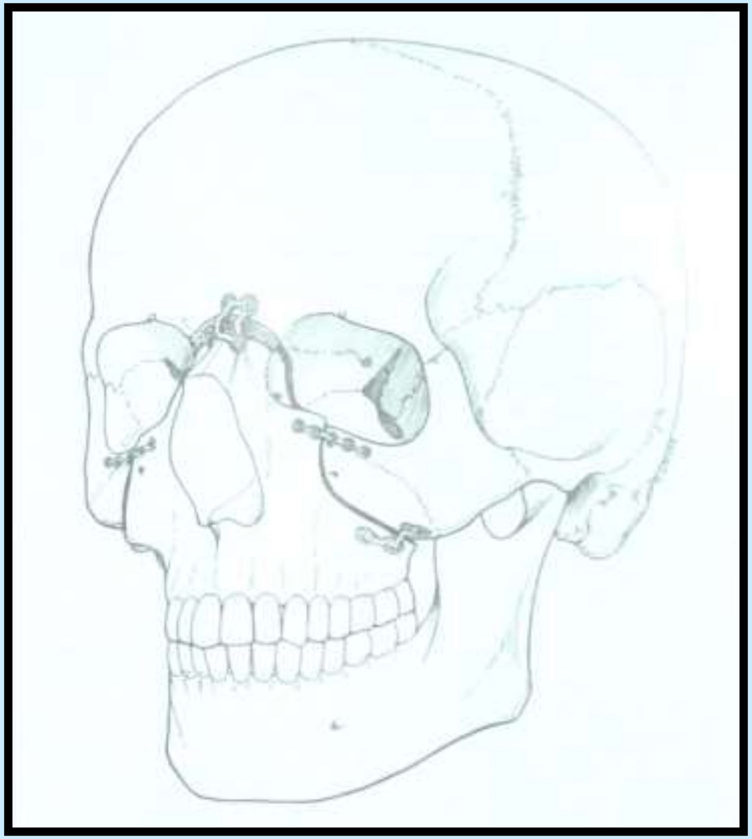
Le Fort II osteotomy

Plates – zygomatis buttress

infraorbital region

Additional support

nasofrontal region



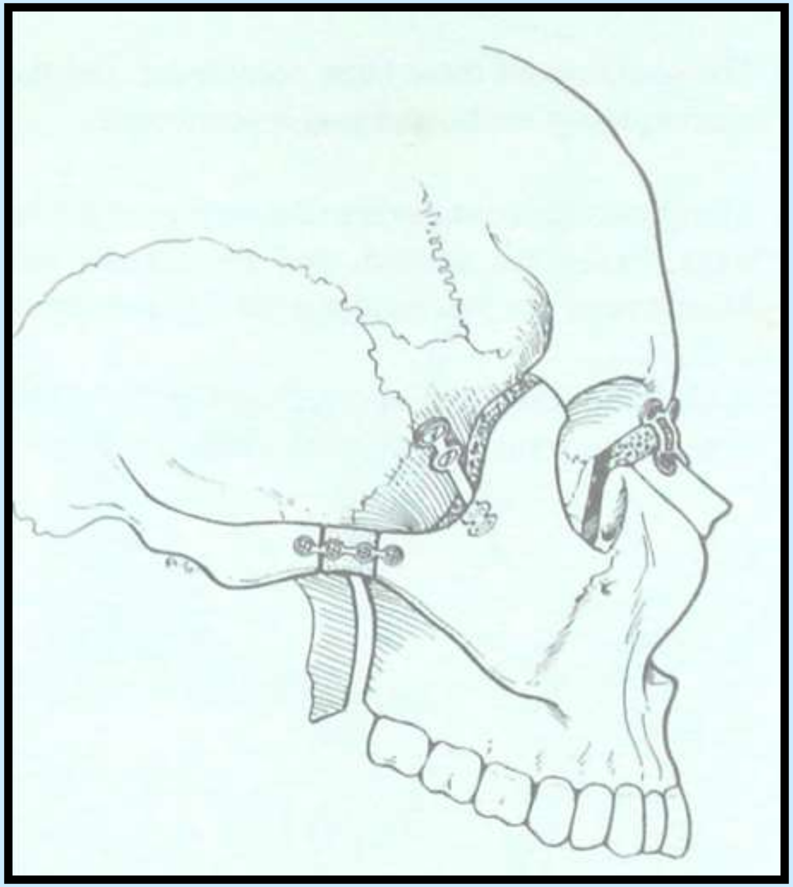
Le Fort III osteotomy

Plates

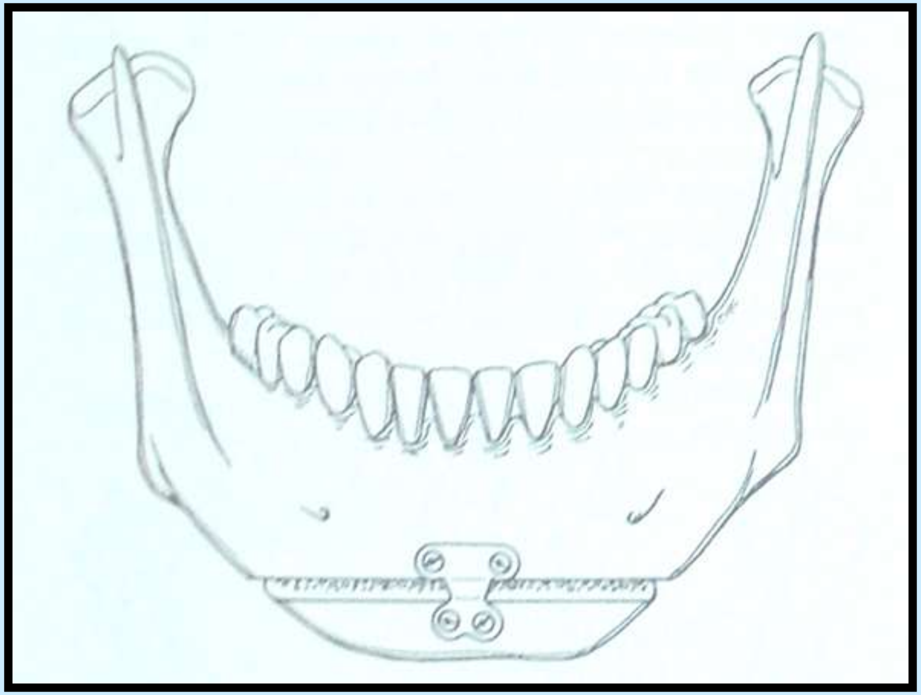
Frontozygomatic

Nasofrontal

Zygomatic arch



Genioplasty

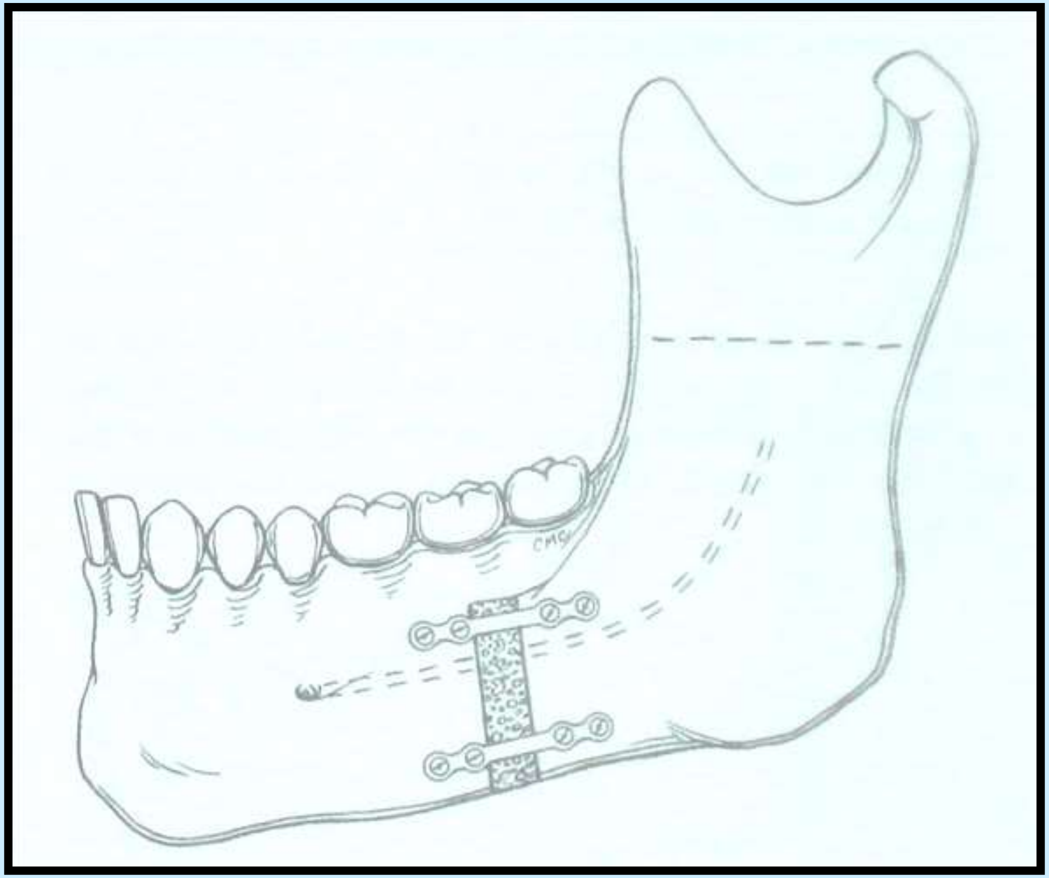


BSSO

Plate

Superior & inferior to

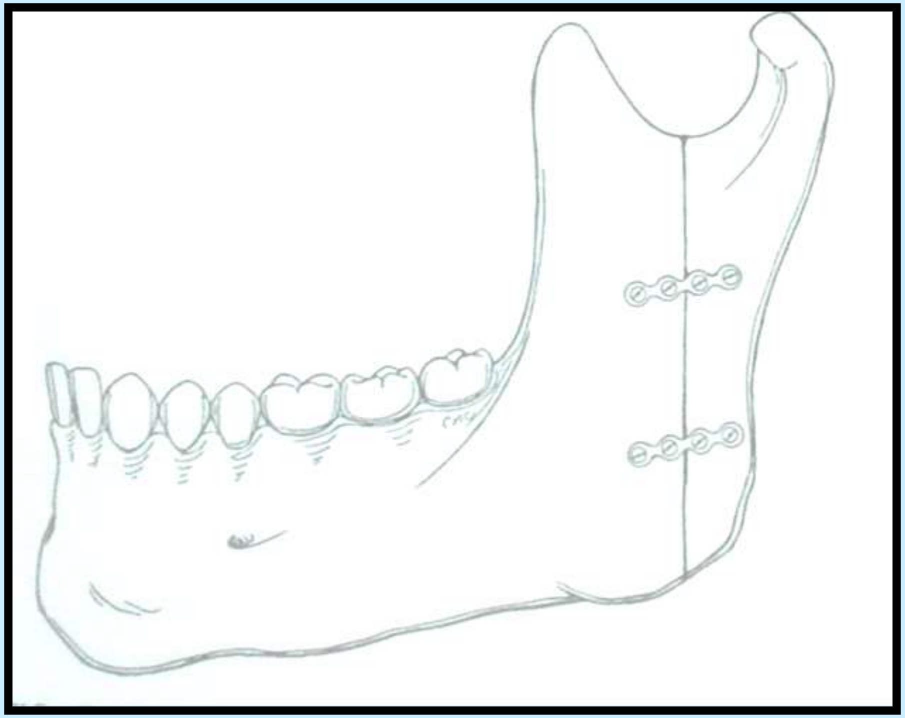
inferior alveolar canal



Vertical ramus osteotomy

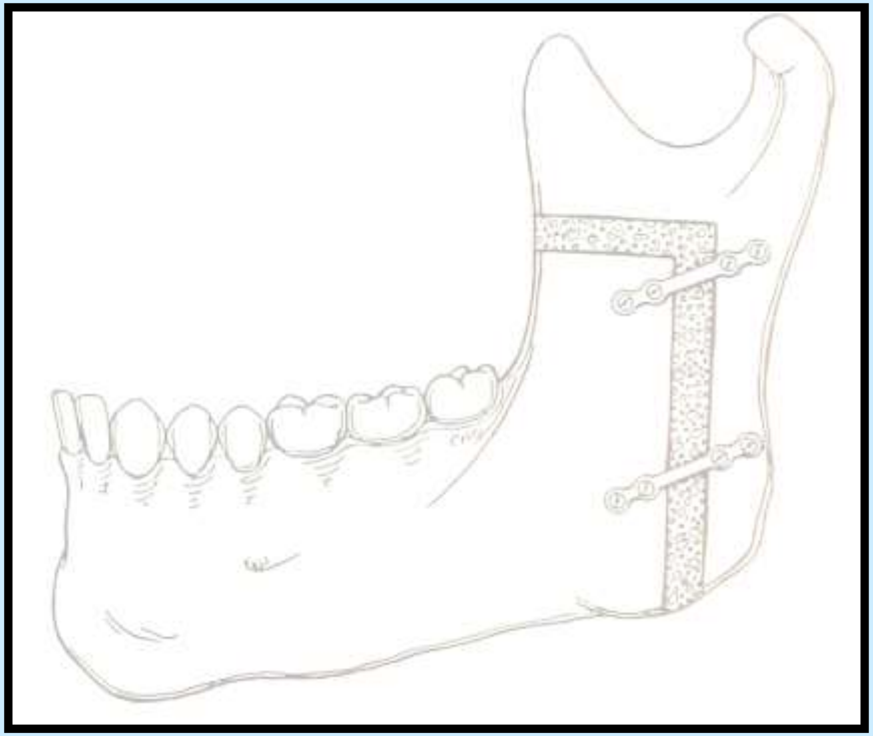
•2 plates across osteotomy site

•Alternatively L & T plates can be used with 2 screws across osteotomy sites

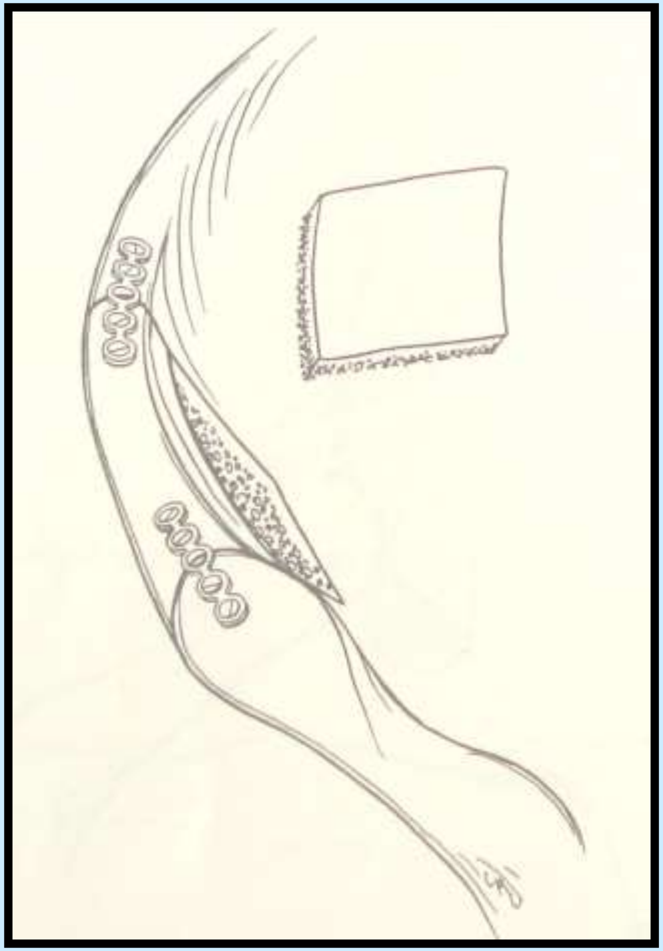


Inverted L osteotomy

- 1 plate at the horizontal osteotomy site
- Second plate inferiorly parallel to the first plate



Fixation of donor site



Cranial surgery

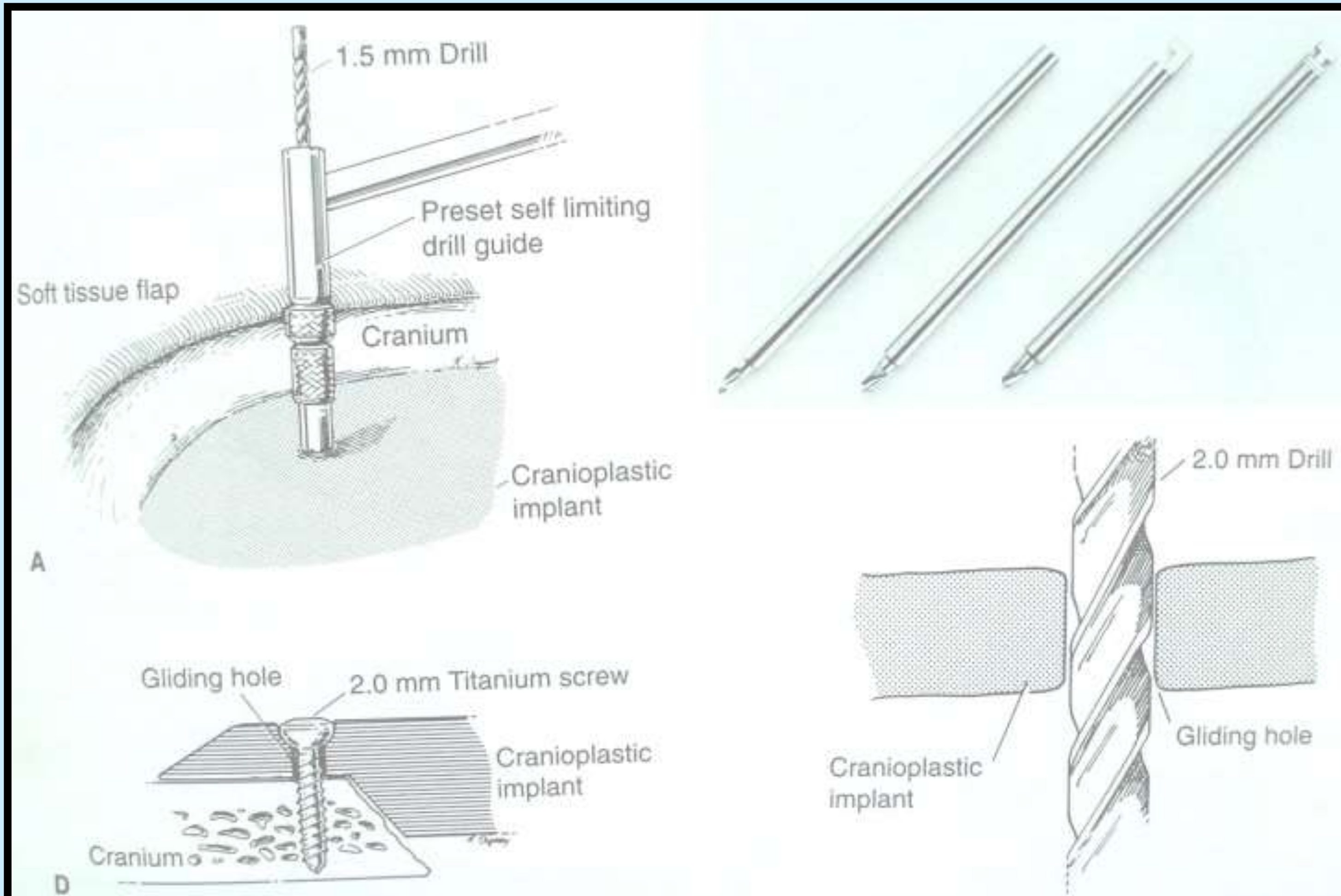


Figure 10.3. A: The preset drill guide with stop is held against the cranioplastic implant flange. A 1.5-mm drill creates a hole in the implant flange and outer cranial cortex. B: Self limiting drill bits may be used without the drill guide. C: The 1.5-mm drill is replaced with the 2.0-mm drill and a gliding hole is placed in the implant. D: The cranioplastic implant is affixed to the cranium with 2.0-mm titanium screws.

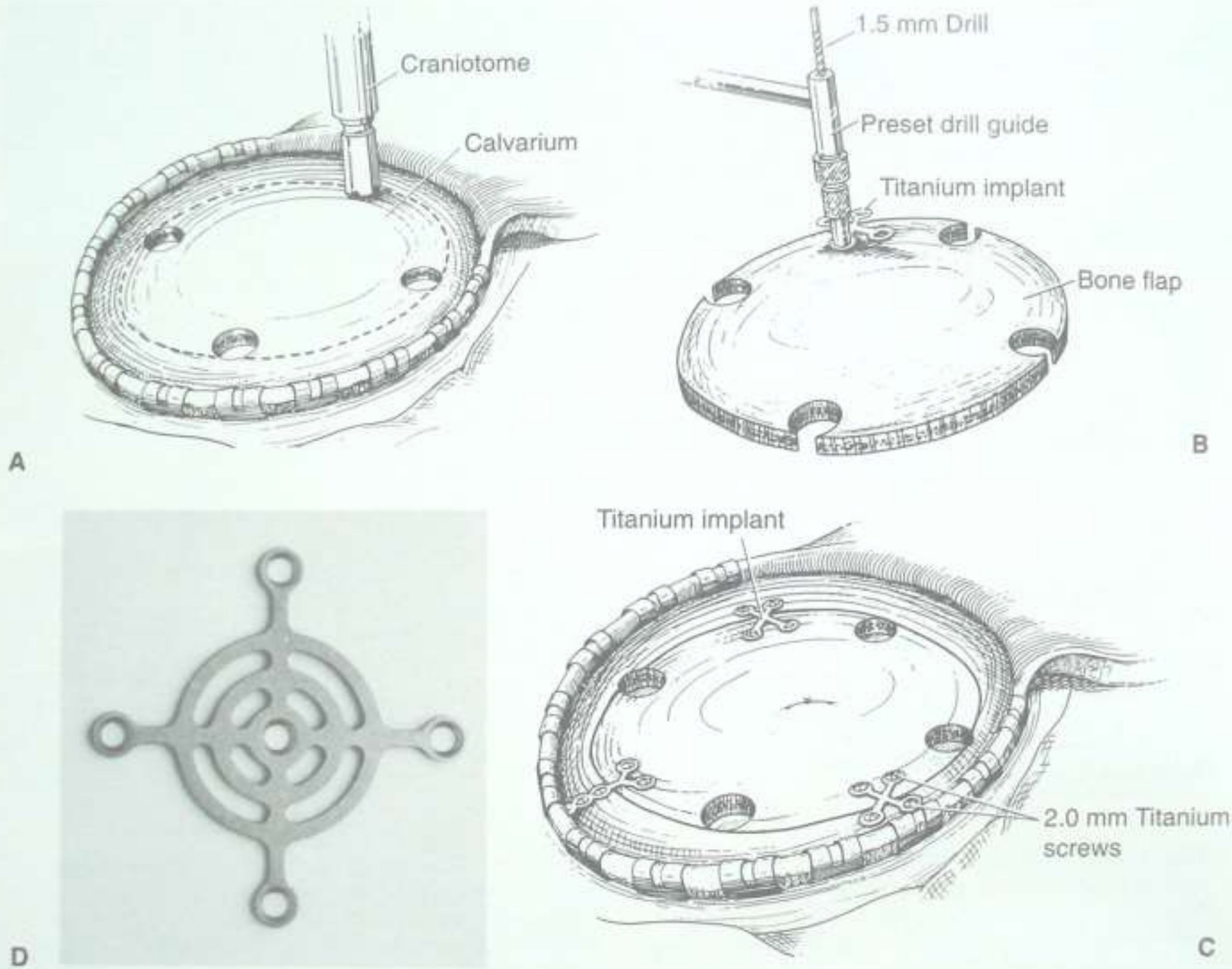


Figure 10.4. A: The craniotome is used to remove the osseous flap. B: The preset drill guide with stop holds the implant to the osseous flap while drilling with the 1.5-mm drill (1.1 in children). C: At least three implants are secured with 2.0-mm screws (1.5 in children). D: Burr hole covers are now available to provide both function and cosmetics. (Courtesy Synthes Maxillofacial, Paoli, PA.)

Depressed skull fracture

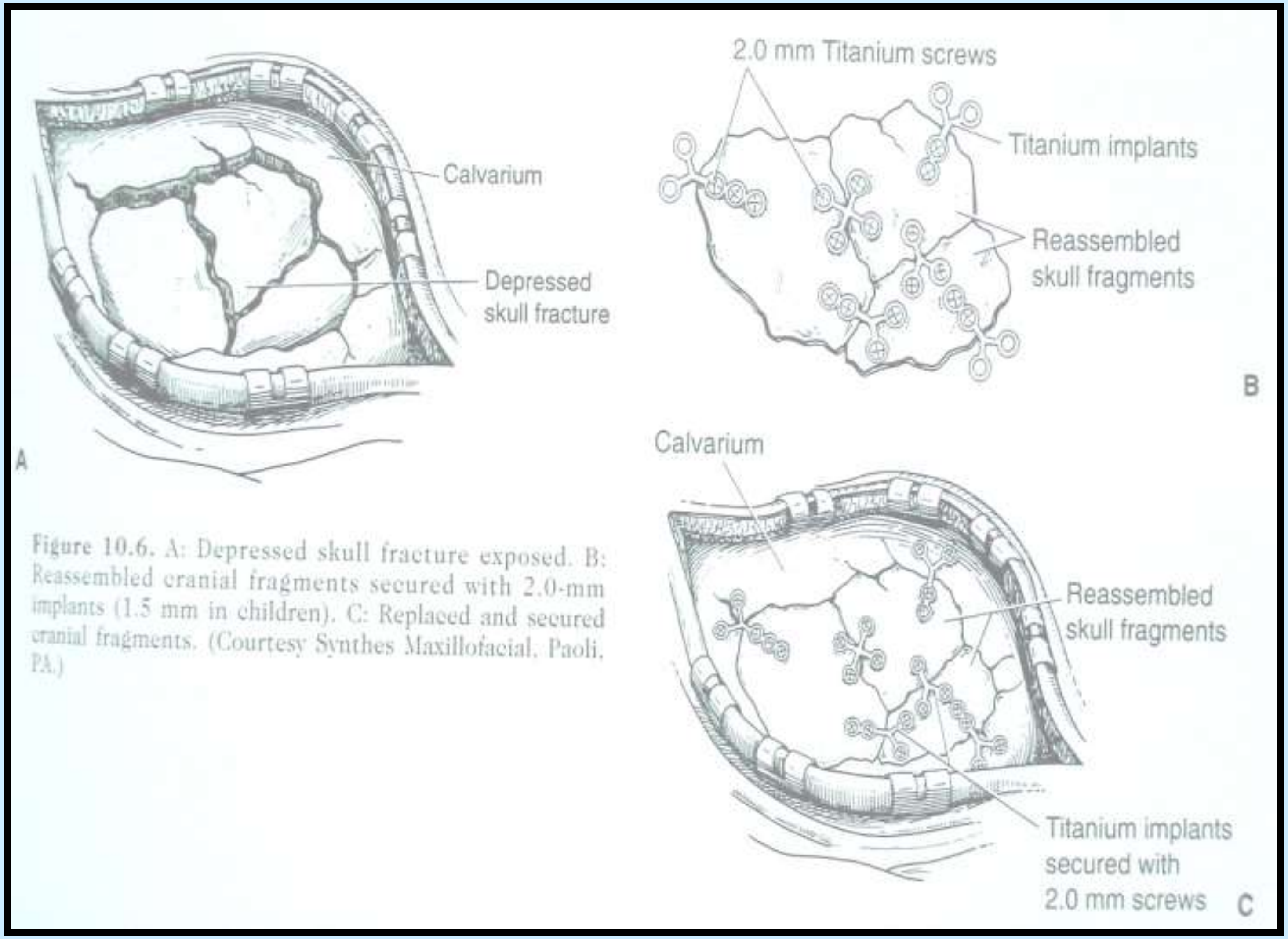


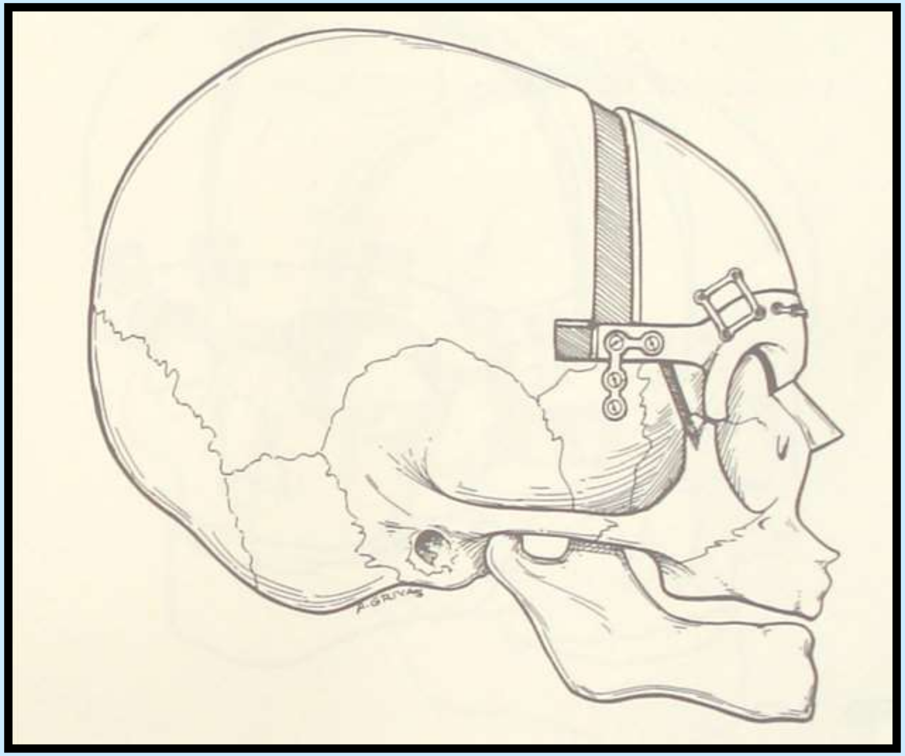
Figure 10.6. A: Depressed skull fracture exposed. B: Reassembled cranial fragments secured with 2.0-mm implants (1.5 mm in children). C: Replaced and secured cranial fragments. (Courtesy Synthes Maxillofacial, Paoli, PA.)

Craniofacial surgery

Fronto-orbital osteotomy

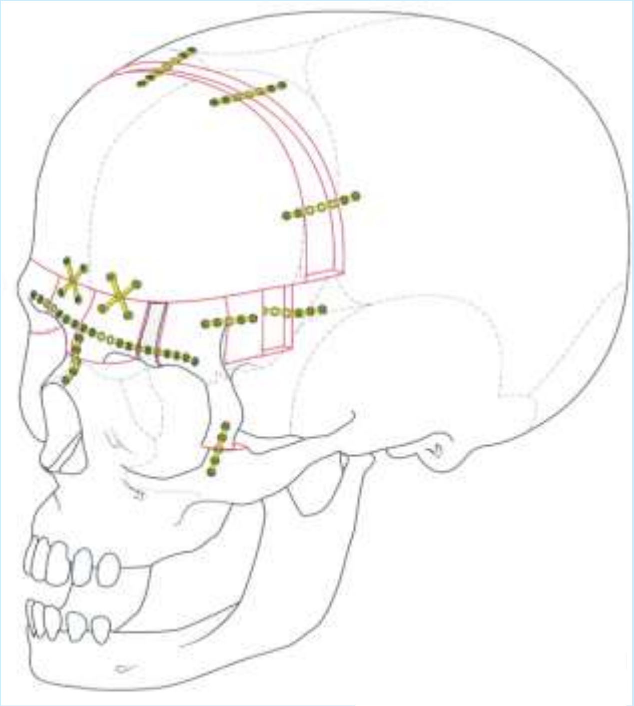
• Orbital bar is fixed to greater wing of sphenoid

• Craniotomy bone flap secured to the orbital bar



Microplate fixation :

- Are used in areas with minimum overlying soft tissue and muscular forces such as orbital rim, anterior maxilla, nasal orbital ethmoid complex.
- Usually made of vitallium – greater strength - allows about 30% decrease in plate profile, 60% reduction in screw diameter.



Advantages

- In severely atrophic mandible it is advantageous as it obviates secondary plate removal prior to prosthesis fabrication.
- Less periosteal stripping
- Decreased risk of neurovascular injury.
- Good 3 dimensional adaptation

Indications

1. Mid face fracture
2. Severely atrophic mandible
3. Stabilization of displaced condylar head
4. Craniomaxillofacial fracture
5. Orbital fracture
6. NOE fracture
7. Cranial fracture

Problems with Metal plates

- Cranial growth restriction
- Intracranial implant migration
- Implant palpability, temperature sensitivity & even visibility in thin skin areas
- Imaging & radiotherapy interference

- Too stiff for optimal healing in some surgical applications - stress shielding may result in bone atrophy and porosis
- Accumulation of metals in tissues
- Adverse effects of metals can necessitate removal operation

Bioresorbable plates

Synthetic biodegradable polymers have been used in surgical applications for the past 30 years as suture materials:

- 1969 - Dexon (Davis & Geck) PGA suture
- 1972 - Vicryl (Ethicon) PGA/PLA 90:10 suture PDS (Ethicon)

In last two decades the use of biodegradable materials has expanded to include fixation applications:

- 1985 – Lactosorb wound closure clips
- 1987 – Ethipin/Orthosorb PDS pin
- 1989 – Biofix SR-PGA pin
- 1994 – Linvatec PLLA interference
- 1995 – Biofix SR-PLLA screw
- 1996 – Lactosorb CMF plates & screws
- 1996 – Bionx Meniscus Arrow

Advantages over metal plates

- No second surgery required for implant removal
- No long term implant palpability or temperature sensitivity
- Non-metallic
- Predictable degradation to provide progressive bone loading & no stress shielding
- Implants supplied sterile

- ✓ Reduced patient trauma & cost
- ✓ Patient satisfaction
- ✓ No imaging interference
- ✓ Improved chance of bone healing
- ✓ Reduced cross infection potential

Different materials available

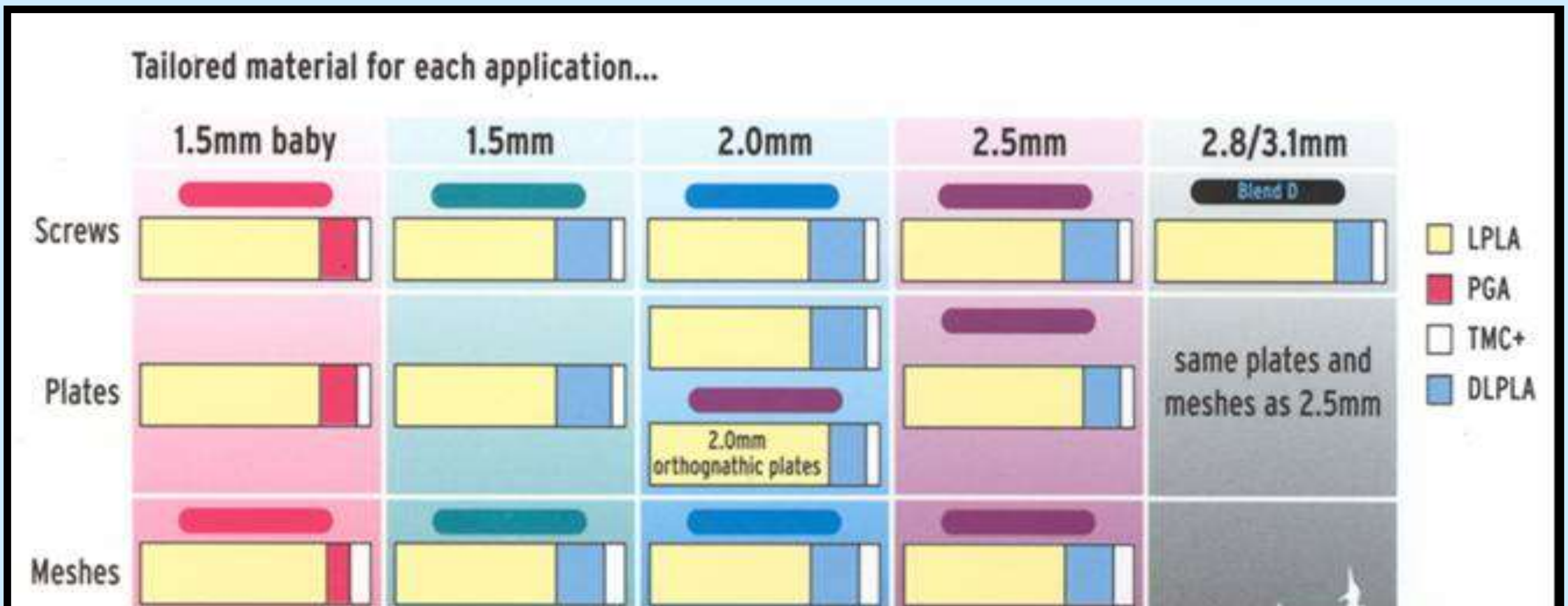
1. Polydioxanone (PDS)
2. Polyglycolic acid (PGA)
3. Polylactic acid (PLA)

Low strength

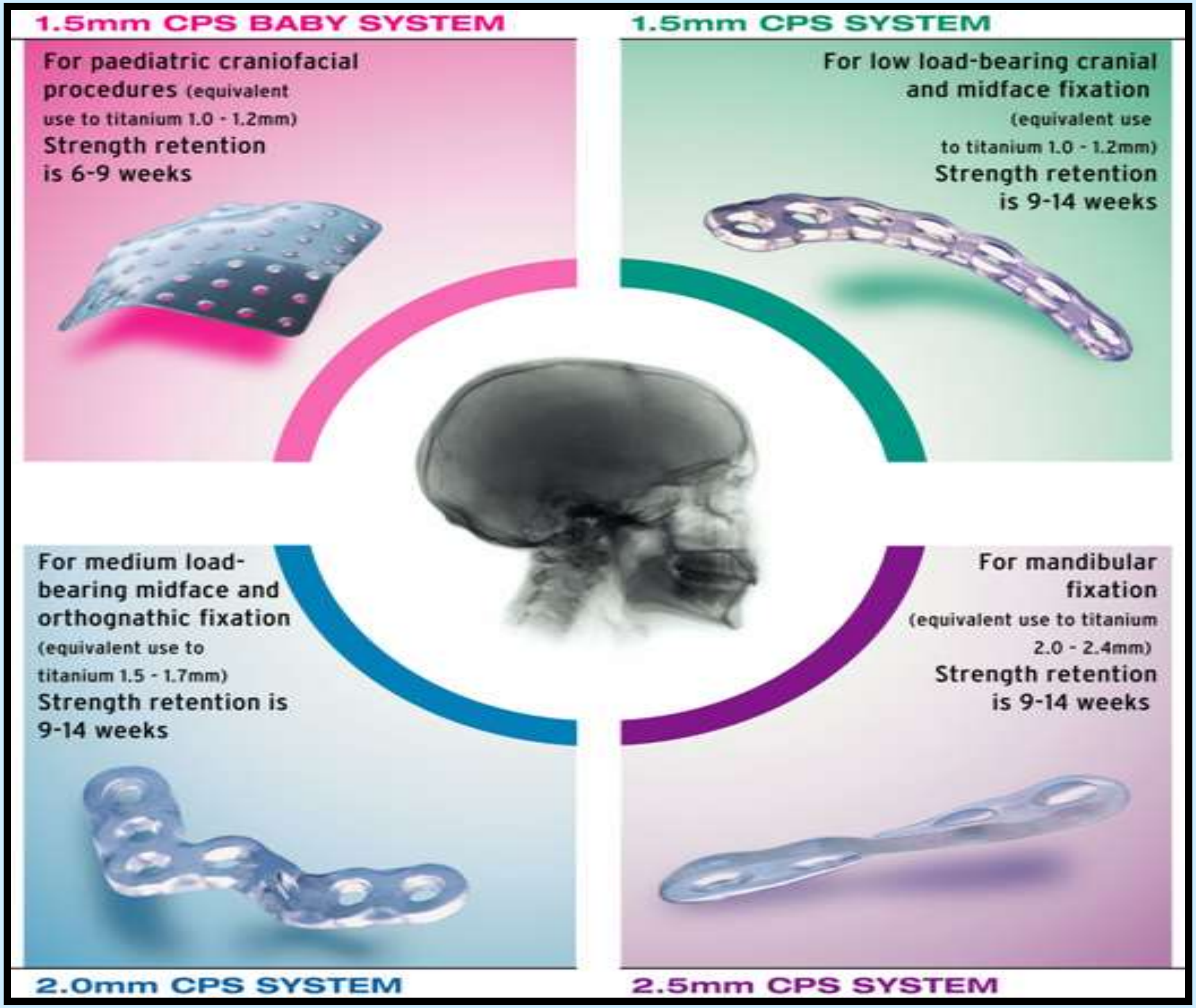
4. Self – reinforced polyglycolic acid (SR-PGA)
5. Self – reinforced Polylactic acid (SR-PLA)
6. Poly L – lactic acid (PLLA)

Tailored Optima^{TM} Material

- L Lactide — Provides strength to implants
- D Lactide — Disrupts crystallinity
- Glycolide — Degrades quickly
- TMC — Provides enhanced malleability



Selection of plates



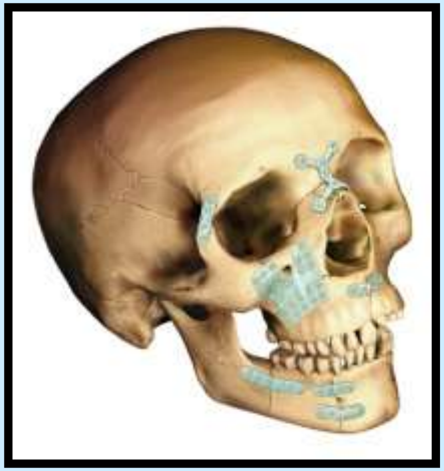
Diversity of application

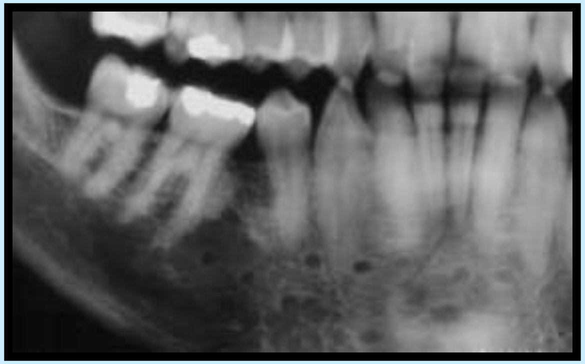
Congenital deformities & growth disturbances

- Craniofacial
- Orthognathic

Trauma

- Mandible
- Zygoma
- Mid Face – Le Fort I,II & III
- Orbital rim
- Naso Ethmoid





Technique

1. Plate Activation

Plates and Meshes are ‘activated’ by heating in the Thermo water bath.

It takes 1-2 minutes for them to be most malleable.

2. Plate Adaptation

The plates are most malleable for 15 seconds after removal from the water bath and can easily be adapted by hand.

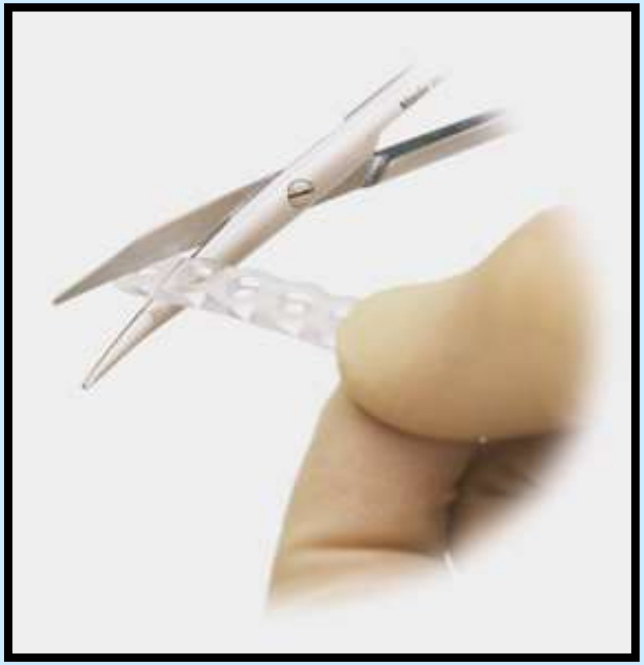
The plate can be re-heated in the water bath at any time.

Briefly dipping part or all of the plate into the water softens the plate for minor adjustments to be made.

Plate Adaptation…

Plates can be cut using surgical scissors .

Plates are easiest to cut when soft on removal from the water bath.



If necessary long screws can be cut to length with scissors or small wire cutters.

3. Screw Preparation

Screws are mounted in a convenient screw-ring

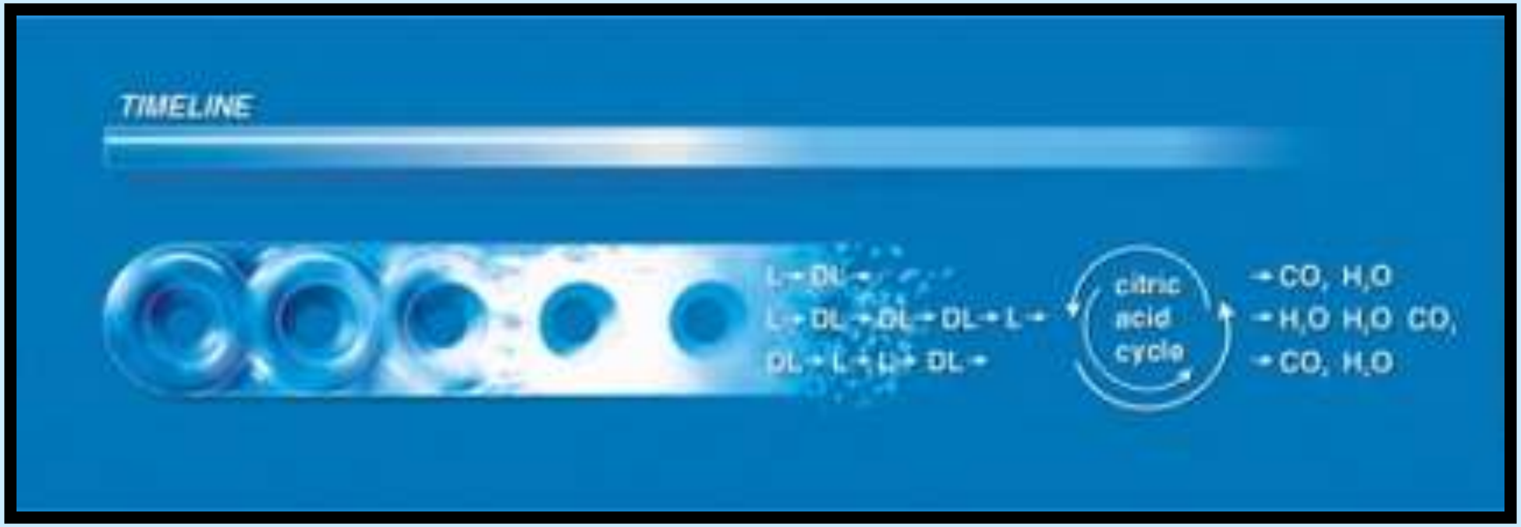
The universal screwdriver is used for all screw sizes

Screws have a simple push-fit pick-up design which gives a very secure hold

4. Plate placement & screw tightening

Degradation process

- **Stage 1 – Hydrolysis**
  - water attacks the chemical bonds converting the long polymer chains into shorter water-soluble fragments
- **Stage 2 – Metabolization**
  - metabolized into monomeric acids which enter the citric acid (Krebs) cycle
- **Stage 3 - Excretion**
  - excreted as water and carbon dioxide



Complication of resorbable plates

1. Inflammation
2. Foreign body reaction
3. Peri implant effusion
4. Osteolytic changes
5. Non specific lymphocytic activation
6. Sterile fluid accumulation
7. Slow resorbtion

COMPLICATIONS OF RIF

1. METAL SENSITIVITY

•Chrome, cobalt, and nickel – components of stainless steel

•Vitallium -Can cause allergic response in some people

Symptoms : Generally localized to implant area – Eczema, erythema and vessicles of overlying skin or mucosa.

Usually occur 3 to 6 months after placement.

2. SCREW FAILURE :

Causes

- improper hole size or screw diameter
- Incomplete tapping of the hole
- Improper hole placement (too close to fracture or osteotomy)
- Poor bone quality
- Improper screw alignment
- Excessive insertional torque resulting in screw fractures
- Functional forces exceeding the load capabilities of the screw.
- Metal stress fatigue

Indicator for screw failure : - Fracture mobility

- Infection

3. PLATE FRACTURE :

- Uncommon complication
- Incidence 0-10%
- Causes – Improper size of plate

  - Excessive bending of plates

  - Metal failure.

4. STRESS SHIELDING :

- A potential complication of RIF is the possibility that plates will absorb the functional stress on the bone, resulting in a disuse osteoporosis termed as stress shielding.
- Protection from stress occurs if the RIF system has higher modulus of elasticity than the bone.

5. INFECTION :

•Incidence – 3 to 27%

Causes

Technical errors

-Inadvertent placement of screws in the line of fracture.

-Poor plate adaptation

-Inadequate cooling of the bone

Other factors

-Retention of infected tooth in fracture line

-Treatment delay

-Concomitant substance abuse

-Poor compliance.

6. SENSORY NERVE INJURY :

Cause: overzelous retraction

incidence of neurosensory deficit after RIF 0.9 to 46.6 %

7. MOTOR NERVE INJURY :

- injury to branches of facial nerve can occur during repair of man & ZMC fracture.
- most vulnerable branches – temporal & marginal mandibular

8. NONUNION, MALUNION & MALOCCLUSION

Nonunion

- Incidence 1-3%
- Causes :-
  - Infection
  - Inadequate rigid fixation
  - Invasion of fibrous tissue in the gap
  - compromised blood supply
  - Communited fracture
- Mobility across fracture segments
- Pain which increases on manipulation of fracture site
- Radiographically – sclerosis of bone ends or increased atrophy above and below fracture site.

Malunion

Causes :

•Poor plate bending

•Plate fracture

•Loosening of screws

•Poor intra op reduction

Incidence : 3.6 to 14%

9. RESTRICTION TO CRANIOFACIAL GROWTH

rigid fixation may affect growth potential of craniofacial skeleton but to a lesser extent then congenital & traumatic anomalies for which it is employed

10. HYPERTROPHIC SCAR FORMATION

Younger pt., pt. with dark skin & pt. with H/O scarring are at risk of developing hypertrophic scar

Prophylactic treatment

a) steroid tapes

b) intralesional injection of 0.1ml of triamcinolone at 2-3 wk interval

11. INJURY TO ROOTS

References

- Oral and maxillofacial trauma , Vol.2 – Fonseca R.J
- Manual of internal fixation in the craniofacial skeleton – J.Prein
- Craniomaxillofacial fractures – Alex M. Greenberg
- Maxillofacial surgery – Vol.1 – Peter ward booth
- Atlas of craniomaxillofacial fixation – Robert M.Kellman
- Oral and maxillofacial surgery, Vol.1 – Peterson.
- OCNA facial plating - Vol.20, No.3, Aug. 1987
- Stability of orthognathic surgery: a review of rigid fixation BJOMS 1996