

Distraction Osteogenesis

Distraction Osteogenesis (DO)

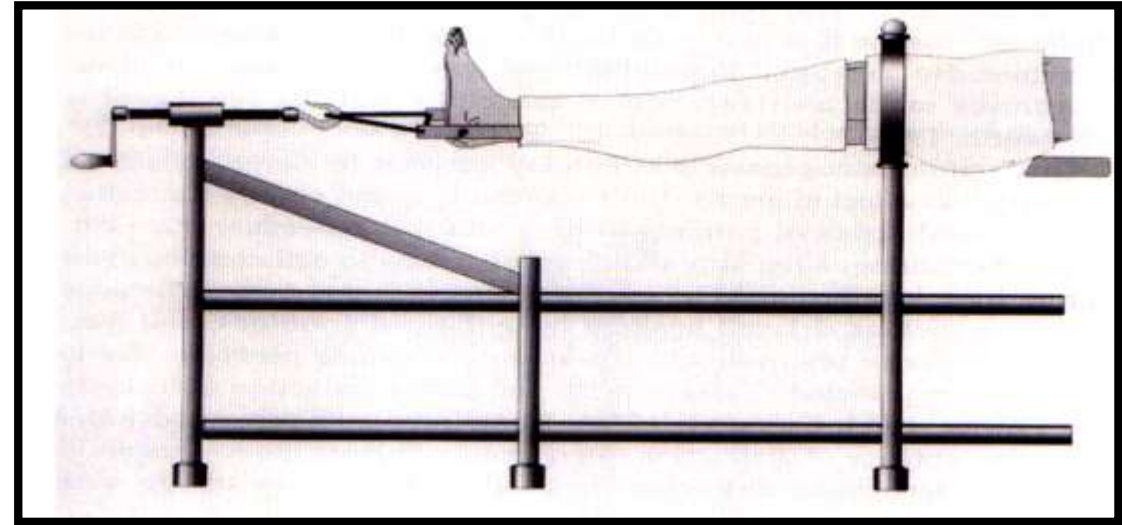
- Procedure that moves two segments of a bone slowly apart in such a way that new bone fills in the gap.

(James Mc Namara)

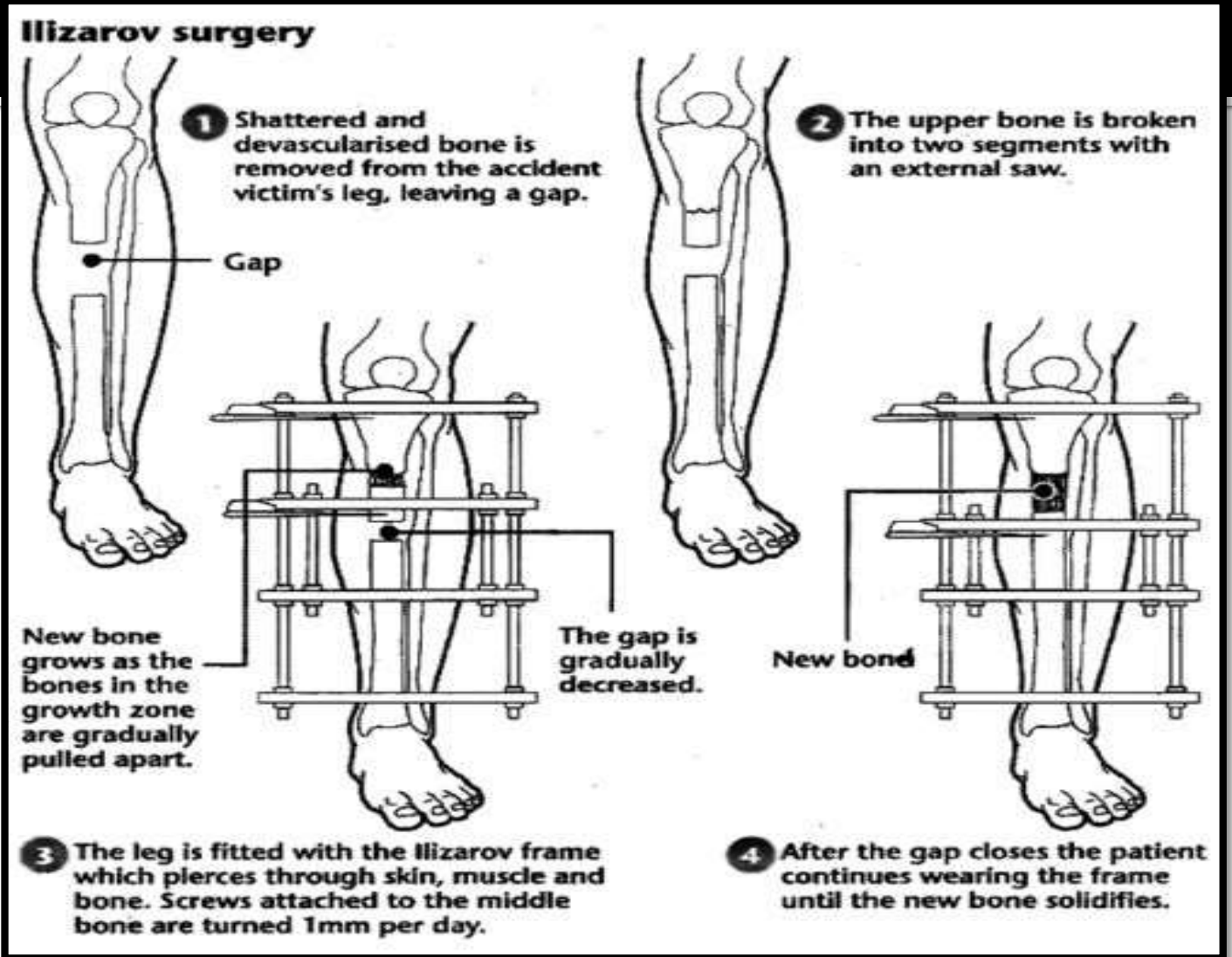
- Other terms - *Callus Distraction, Callotaxis, Osteodistraction*
- Distraction Osteogenesis is the technique of bone lengthening in which osteotomized bone is moved apart and there is new bone generated between two separated bony ends.
- Ilizarov : **Osteodistraction** utilizes the body's own repair mechanism for generation of new bone. Along with new bone there is regeneration of soft tissues – skin, mucosa, muscle and neurovascular bundle (*Distraction Histogenesis*).

History

- *Ancient Roman* - Limb lengthening
- *Hippocrates (2000 yrs ago)* - Traction forces to broken bones
- *Guy de Chauliac (14th century)* - Pulley and Weight system
- *J R Barton (1826)* - Surgical division of Bone (*Osteotomy*)
- *Joseph Malgaigne (1847)* - External Skeletal Fixation
- *Codivilla (1905)* - First performed limb lengthening of Femur
- *Ilizarov (1951)* – Pioneer in DO
- *Mc Carthy et al (1992)* - First clinical application of mandibular lengthening
in syndromic patients & efficacy of multi directional appliance



Ilizarov 1951

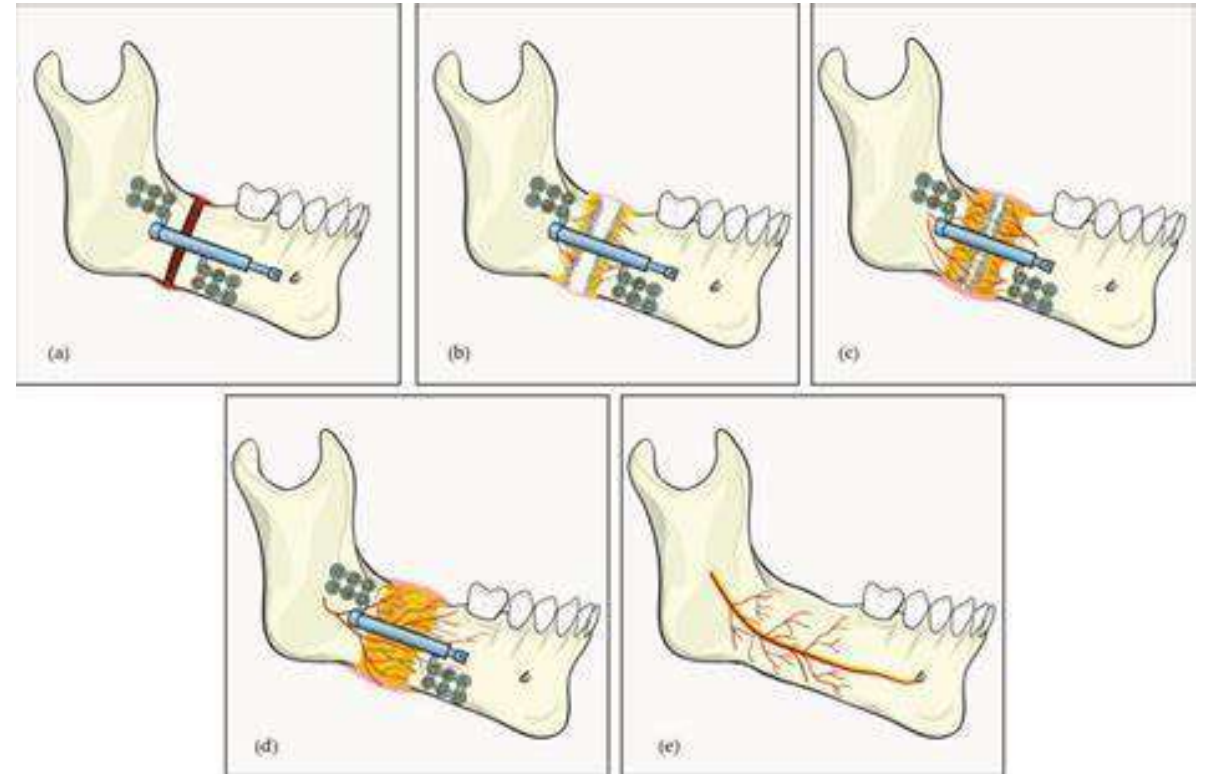


EXTERNAL RING FIXATOR

Phases of Distraction Osteogenesis

■ Consists of five sequential stages –

1. Osteotomy
2. Latency period
3. Distraction phase
4. Consolidation phase
5. Remodeling phase

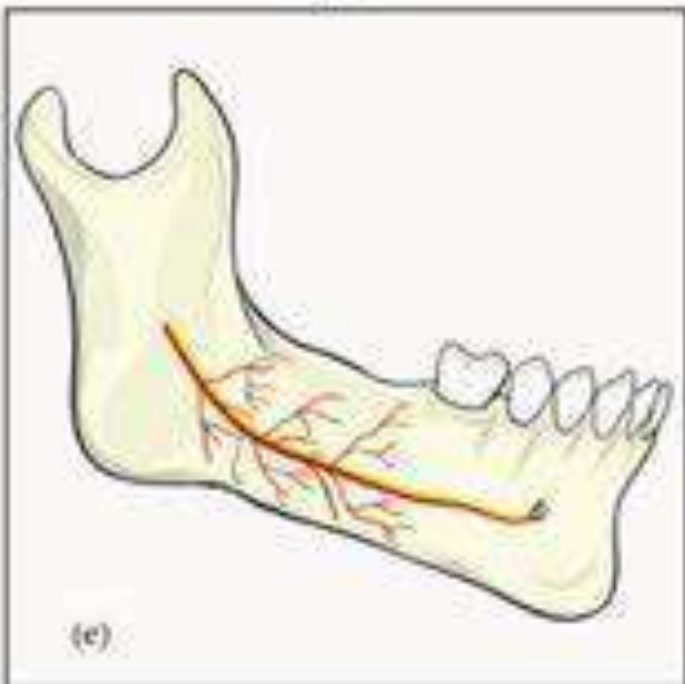
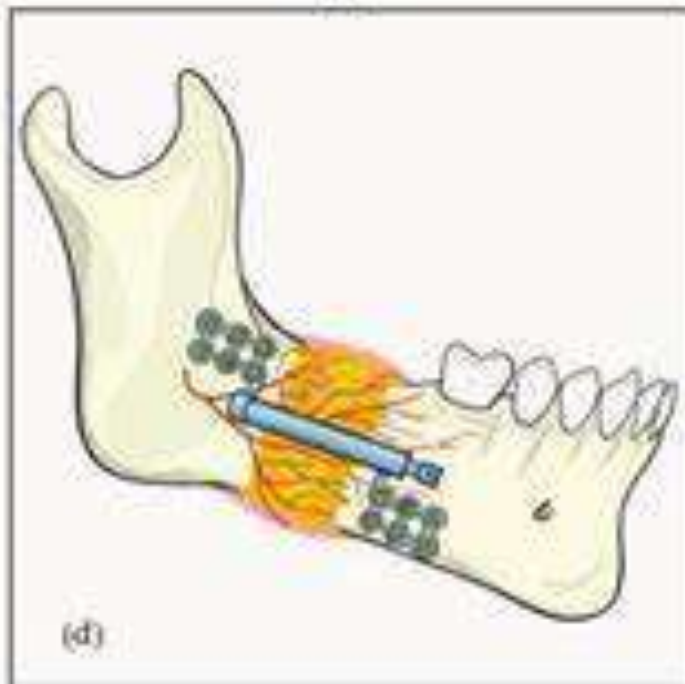
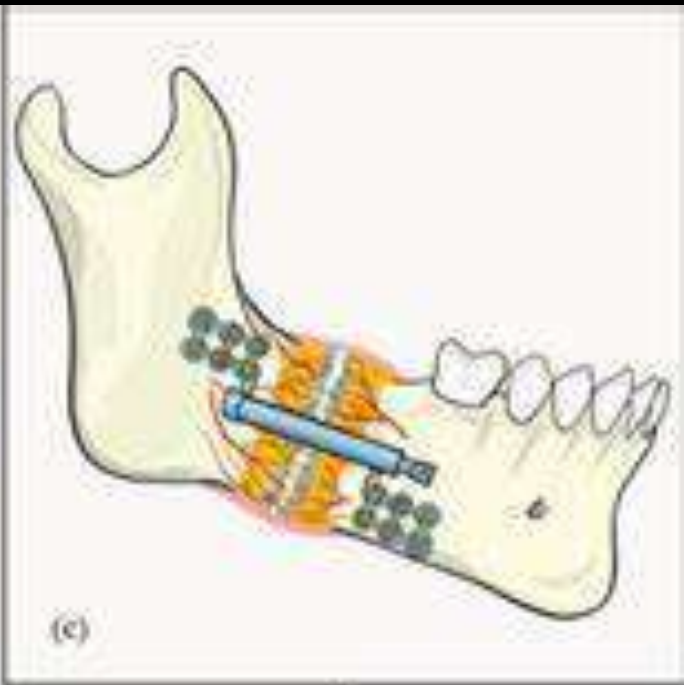
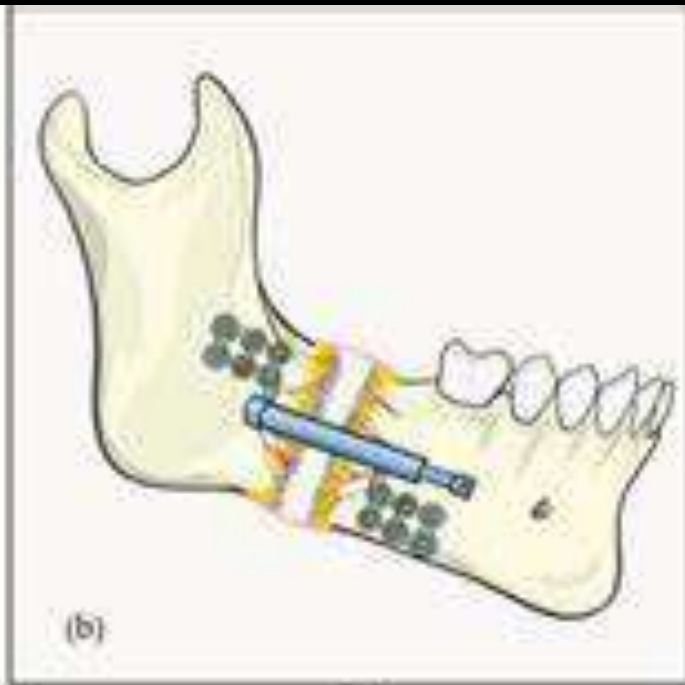
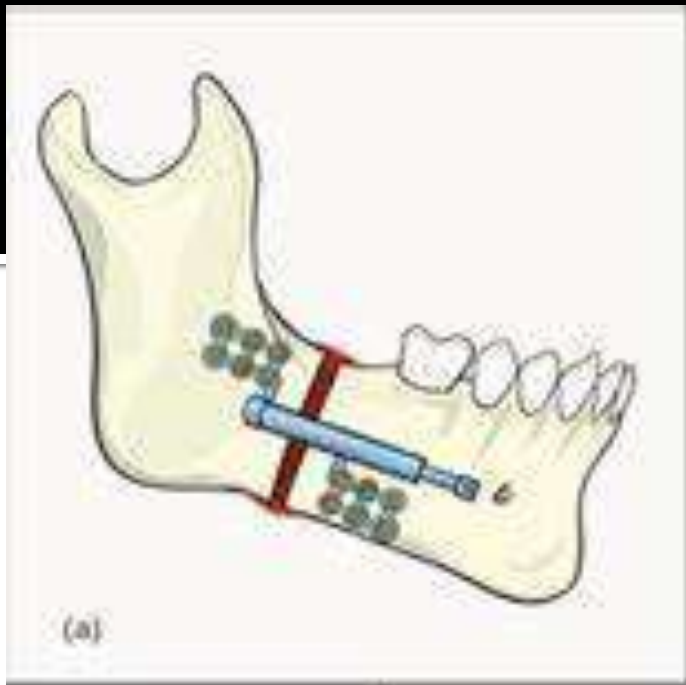


1. Osteotomy

- An *osteotomy* divides a bone into two segments, resulting in a loss of continuity and mechanical integrity; this is also referred to as a fracture
- Discontinuity of a skeletal segment triggers an evolutionary process of bone repair known as *fracture healing*

2. Latency Phase

- The latency period is the period from bone division to the onset of traction.
(represents the time allowed for reparative callus formation)
- Initially, as a result of vascular disruption, a hematoma forms between and around the bone segments. The hematoma is converted to a clot and bony necrosis occurs at the ends of the fracture segments.
- Lasts from 1 to 3 days, at which time the clot is replaced with granulation tissue consisting of inflammatory cells, fibroblasts, collagen and invading capillaries.



3. Distraction phase

- The distraction period is characterized by the application of traction forces to osteotomized bone segments
- Bone segments are gradually pulled apart, resulting in formation of new bony tissues within the progressively increasing inter segmentary gap
- Gap strain must be below 2% for bone formation

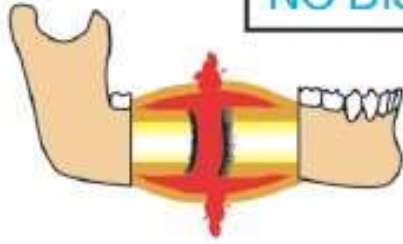
4. Consolidation Phase

- The consolidation period is that time between cessation of traction forces and removal of the distraction device
- This period represents the time required for complete mineralization of the distraction regenerate.
- After distraction ceases, the fibrous inter zone gradually ossifies and completely bridges the gap
- Distracted regions often depict predominantly membranous form of ossification where isolated islands of cartilage may be observed

5. Remodelling Phase

- The remodeling period is the period from the application of full functional loading to the complete remodeling of the newly formed bone.
- Initially formed bony scaffold is reinforced by parallel-fibered lamellar bone. Both the cortical bone and marrow cavity are restored.
- Haversian Remodelling represents the last stage of conical reconstruction and normalizes the bone structure. It takes a *year or more* before the structure of newly formed bony tissue is comparable to that of the preexisting bone

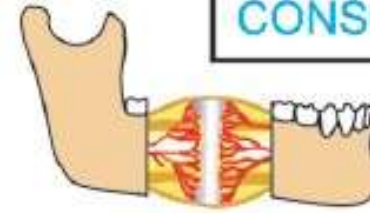
NO DISTRACTION



a

Formation of haematoma in the gap

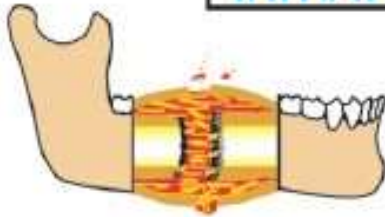
NO DISTRACTION,
CONSOLIDATION



d

Stage of hard callus formation

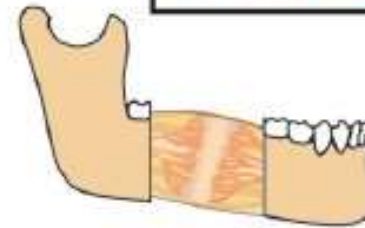
INITIATE DISTRACTION



b

Stage of inflammation

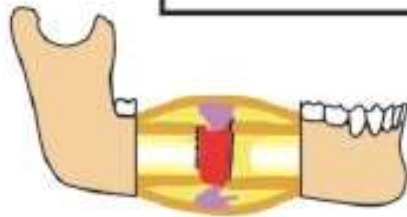
REMOVE DISTRACTOR



e

Gradual corticalization of regenerate

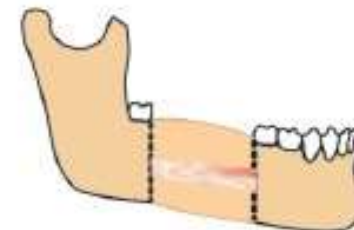
CONTINUE DISTRACTION



c

Stage of soft callus formation

REMODELING PERIOD



f

Formation of medullary canal

Ilizarov's principle

- **Osteotomy** of bone- *minimal periosteal stripping*
- **Latency period:** 3, 5, or 7 days, depending on the surgical site
- **Distraction rate:** 1.0 mm per day- **IDEAL** (0.5–2.0 mm)
- **Distraction rhythm:** “continuous force application”- best twice daily activation- practical; better pt compliance
- **Consolidation:** Cortical outline- radiographically across the distraction gap at 6 weeks

Fracture healing v/s Distraction Healing

- During normal fracture healing, the fibro cartilaginous tissue of the soft callus is replaced by osteoblasts into fibrous bone (hard callus stage). The cartilage calcifies as capillaries invade and osteoblasts lay down new bone on the calcified cartilage matrix.
- **Osteodistraction - the normal process of fracture healing is interrupted by the application of gradual traction to the soft callus**
- A dynamic microenvironment is created.
- The tension stress that develops in the gradually stretched tissues stimulates changes at the cellular and subcellular levels.
- New tissue formation in a direction parallel to the vector of traction. As distraction begins, the fibrous tissue of the soft callus becomes longitudinally oriented along the axis of distraction

Types of Distraction Osteogenesis

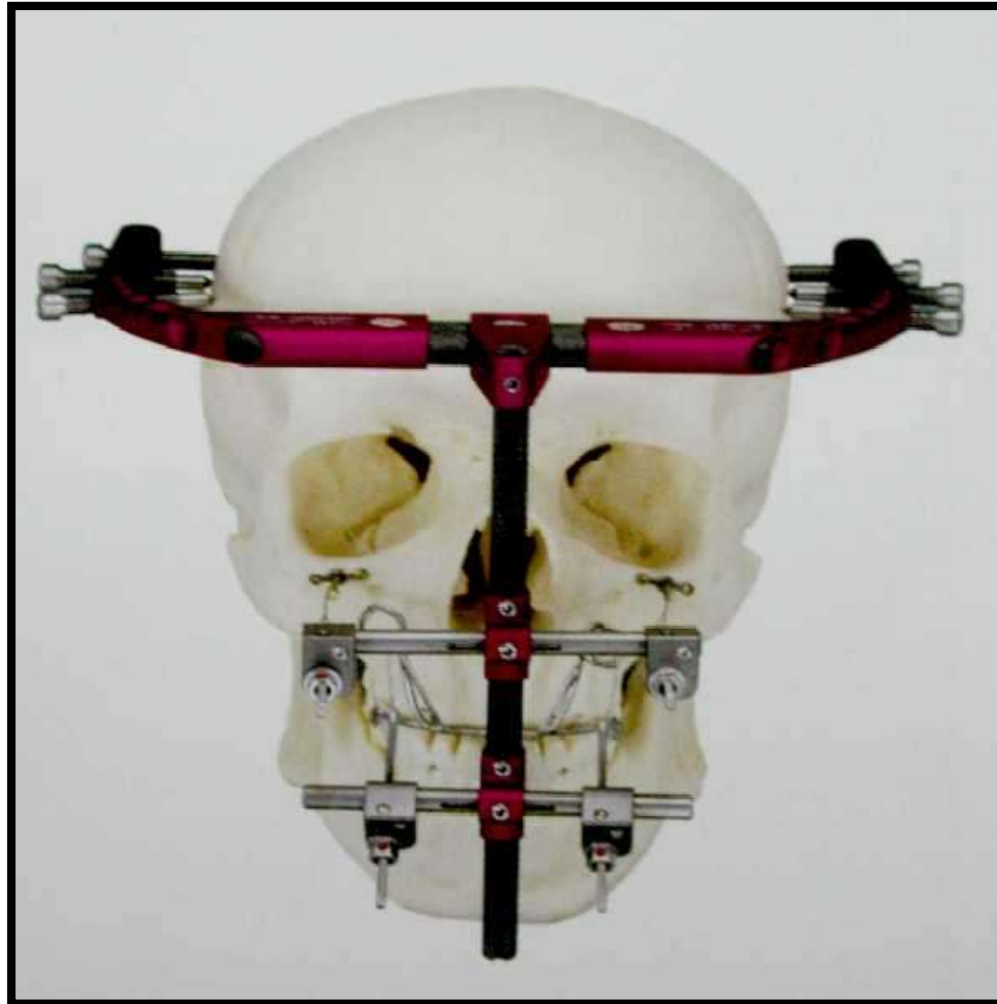
Based on *Location*

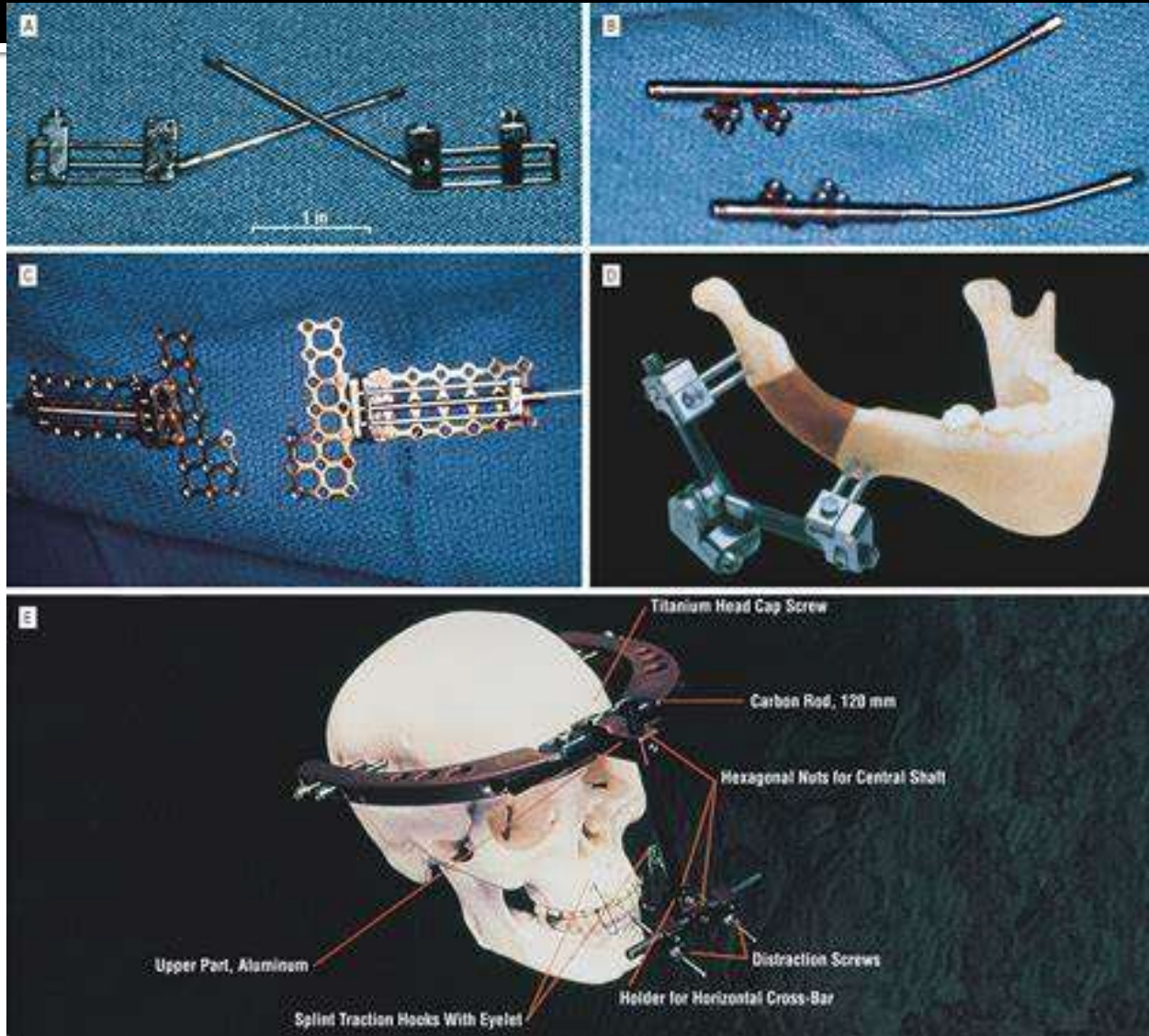
1. External
2. Internal
 - Subcutaneous
 - Intra oral –
 - Sub mucosal
 - Extra mucosal
 - a. Tooth borne
 - b. Bone borne
 - c. Hybrid

Based on *Direction Vector*

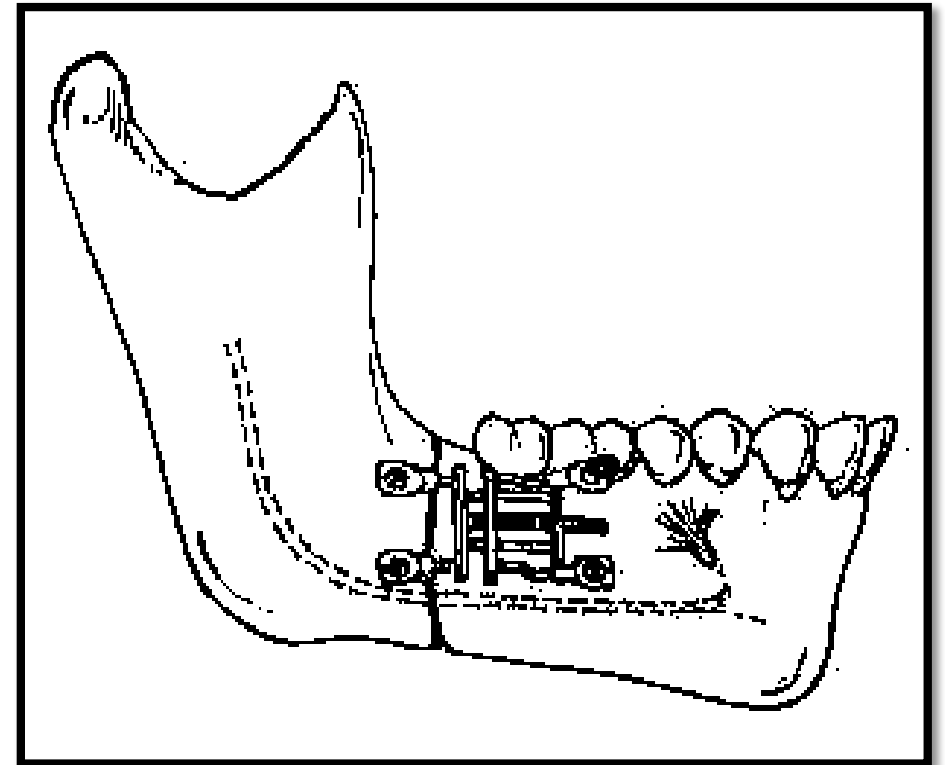
- Monofocal
- Bifocal
- Trifocal

Rigid external Distractor



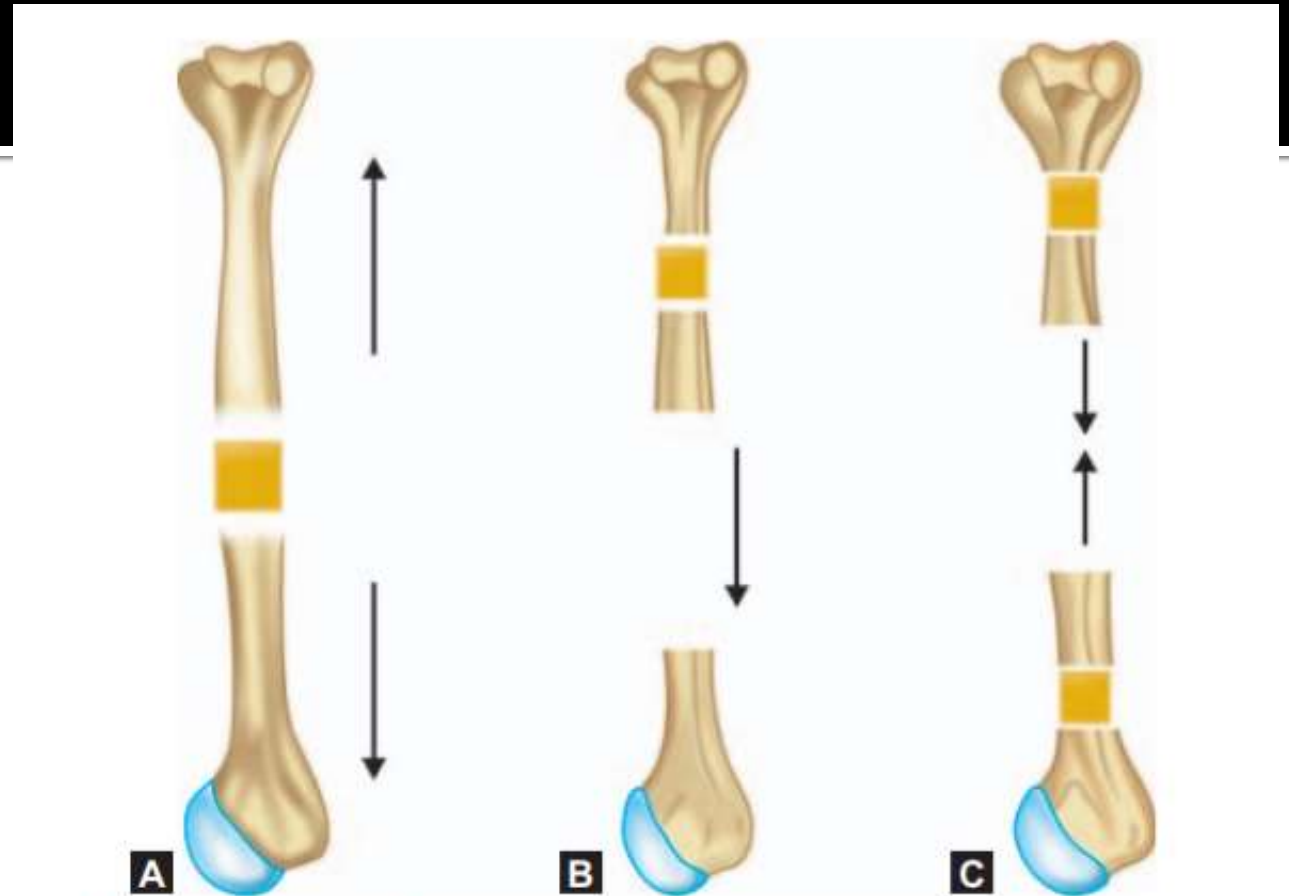


Intra-oral Distractor

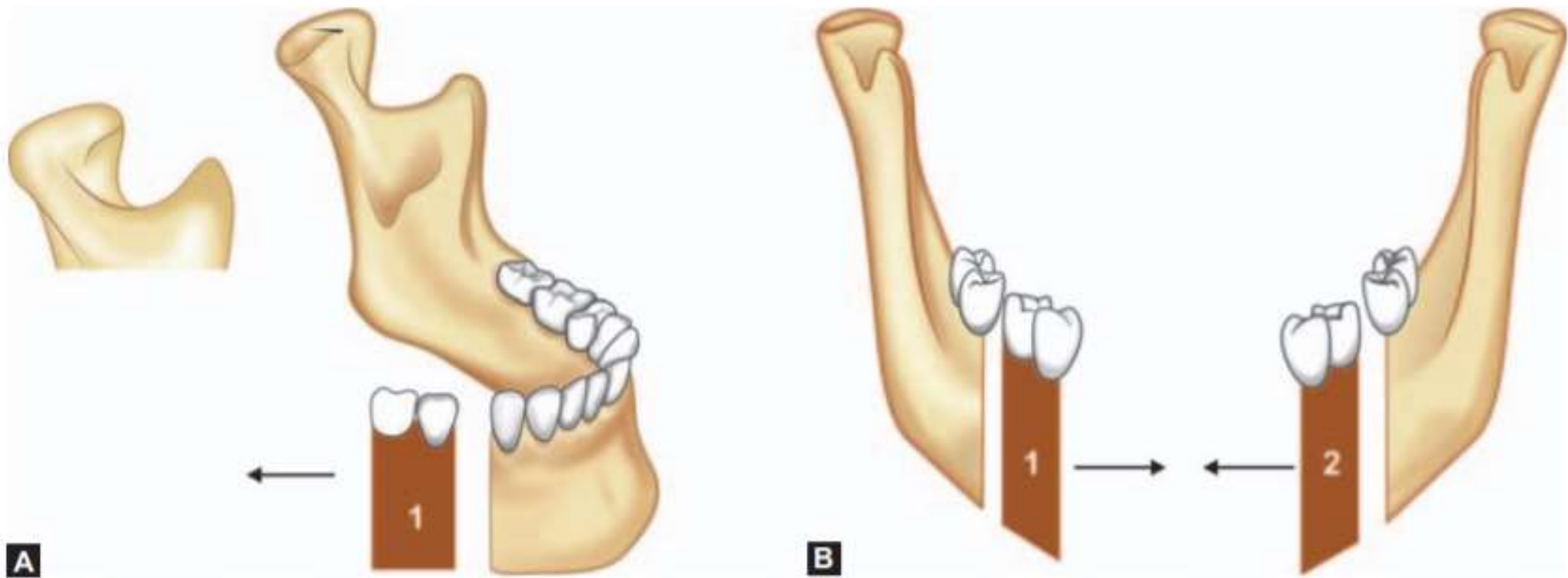


Direction Vector

- Monofocal : A single osteotomy is done and bone segments are separated by incremental traction
- Bifocal : continuity defect is managed by moving a small part of bone. This segment is called transport disk.
- Trifocal: Two transport disks are moved from either side



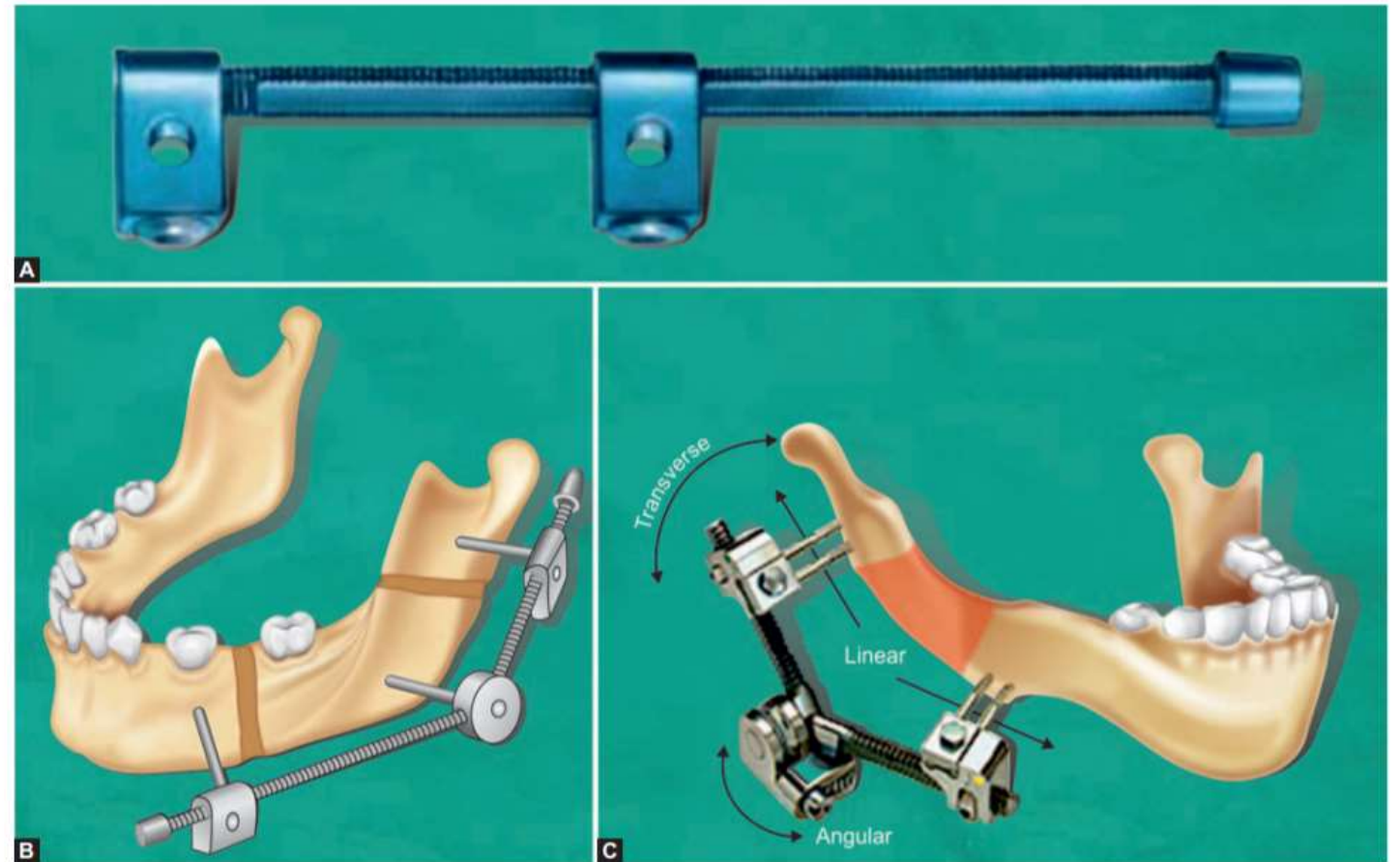
Figs 28.1A to C: Concept of monofocal, bifocal and trifocal distraction. Two segments of bone after osteotomy are separated with the help of distraction device. Callus (yellow colored) is converted into new bone during the consolidation period. (A) Monofocal distraction and callus' (B) bifocal; and (C) Trifocal type of distraction



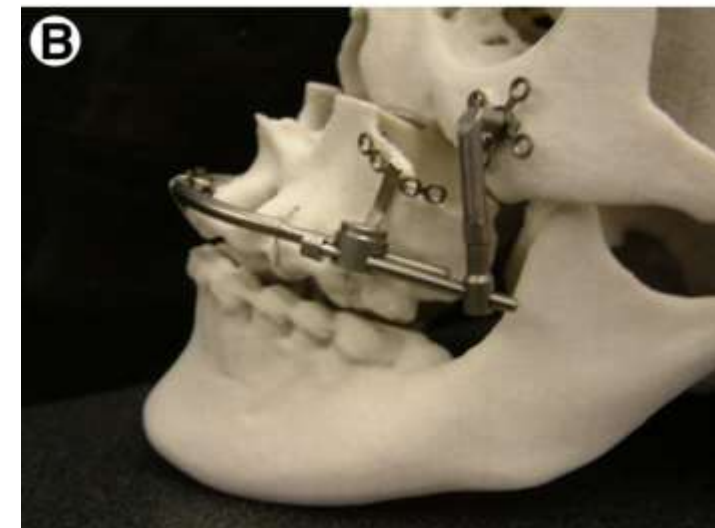
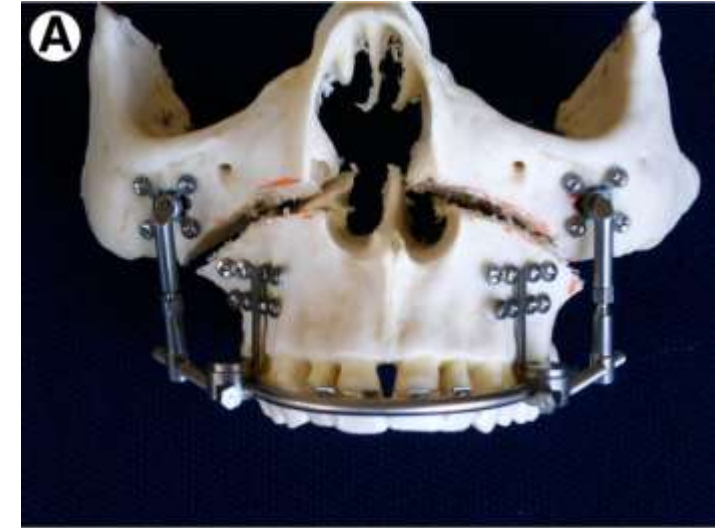
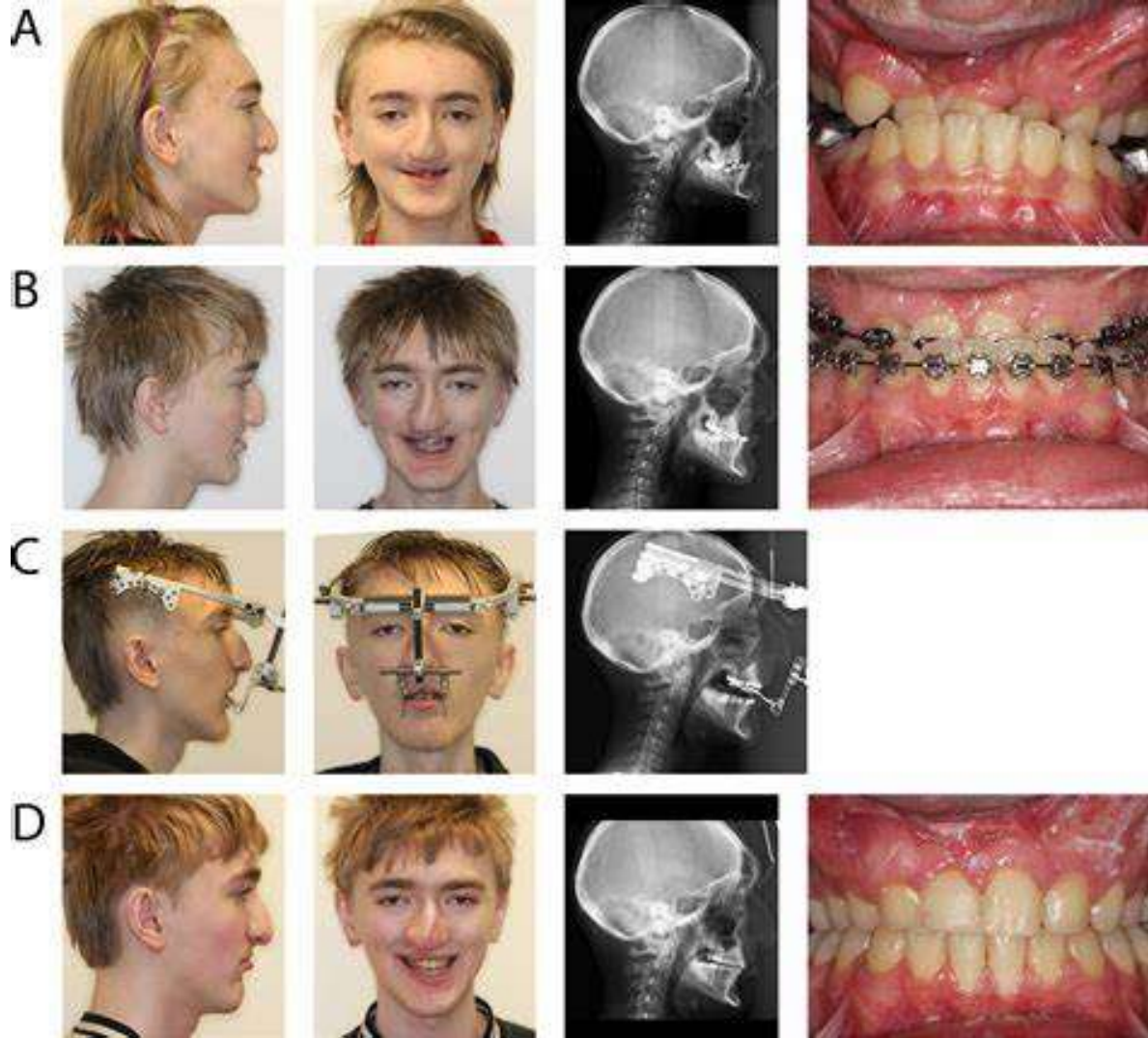
Figs 28.2A and B: Bifocal and trifocal types of distraction as applied to the mandible. Transport disk is pushed to fill the bony defect with new regenerate. (A) In bifocal distraction, there is one transport disk on one end of defect, whereas; (B) in trifocal distraction, there are two transport disks on either side of bone defect

Types of Distraction Devices :

1. Relation with skin surface:
 1. External
 2. Internal
2. Type of anchoring tissues
 1. Tooth borne
 2. Bone borne
3. Vector direction
 1. Unidirectional
 2. Bi-directional
 3. Multivector
4. Purpose/site:
 1. Maxillary
 2. Mandibular
 3. Alveolar



Maxillary Distraction



Mandibular distraction

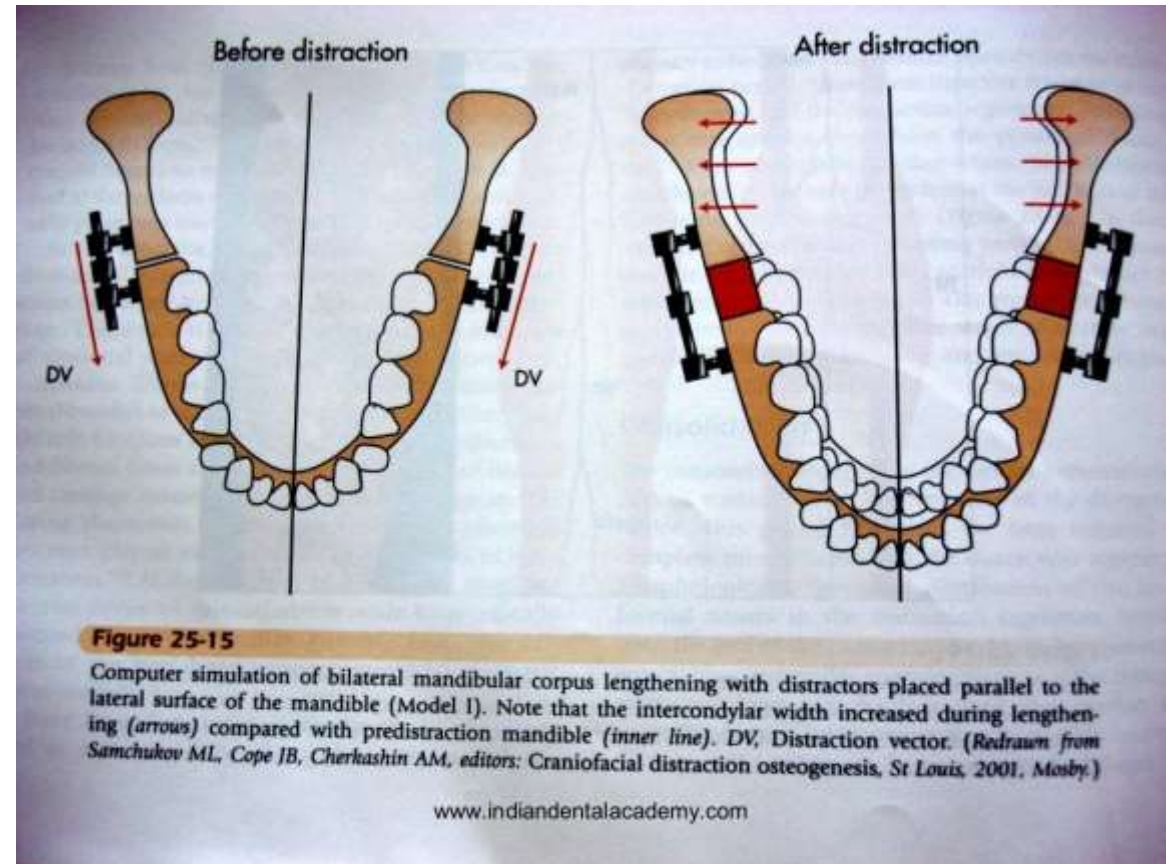


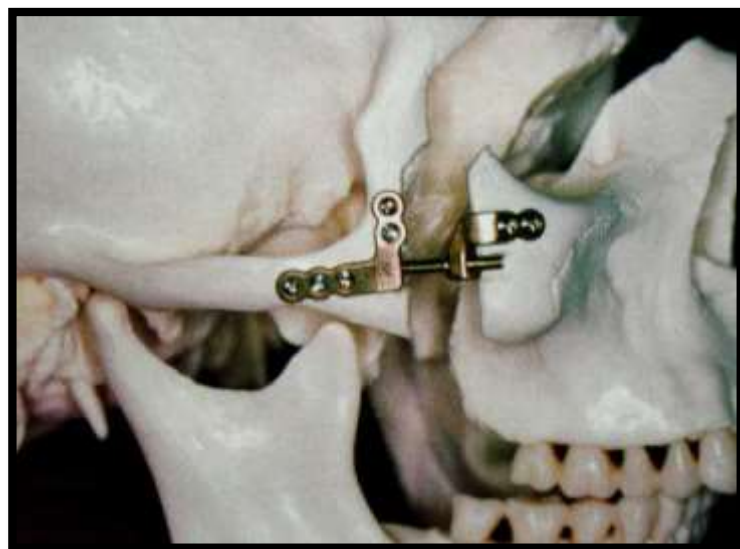
Figure 25-15

Computer simulation of bilateral mandibular corpus lengthening with distractors placed parallel to the lateral surface of the mandible (Model 1). Note that the intercondylar width increased during lengthening (arrows) compared with predistraction mandible (inner line). DV, Distraction vector. (Redrawn from Samchukov ML, Cope JB, Cherkashin AM, editors: Craniofacial distraction osteogenesis, St Louis, 2001, Mosby.)

Alveolar distraction



Mid-face distractor



Conclusion

- Distraction osteogenesis is a surgical orthopedic procedure with :
 - *Maximum preservation of osteogenic tissue*
 - *Stable fixation of bone segments*
 - *Adequate and precise distraction protocols*
 - *Highly technique sensitive*
 - *Patient compliance - of paramount importance*

Thank you!