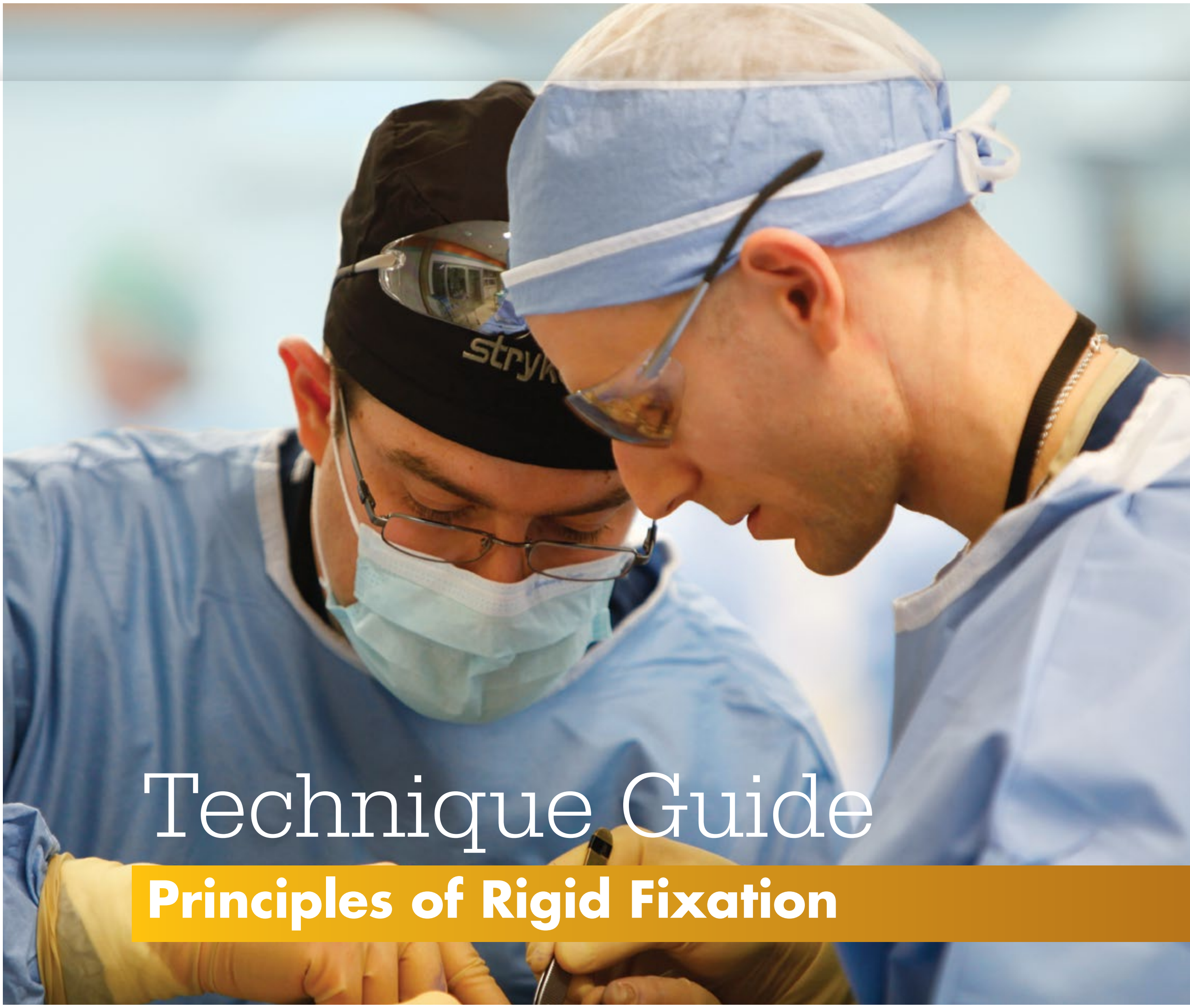


Technique Guide

Principles of Rigid Fixation

Table of contents

Section I:

Evolution of craniomaxillofacial fixation

Evolution of craniomaxillofacial fixation

- **Semi-rigid fixation using wire**
- **External fixation devices**
- **Stainless steel plating systems**
  - Strong and malleable
  - Fear of corrosion & potential toxicity led most manufacturers who previously used stainless steel to convert to titanium
- **Vitallium plating systems**
  - Trade name for a cobalt, chromium, and molybdenum alloy used by Leibinger to create the Luhr plating system
  - Greater tensile strength than titanium; allowing implants for similar applications to be thinner than first titanium implants on the market
  - Biocompatible, although osseointegration has not been found
- **Titanium plating systems**
  - Pure titanium has the best corrosion resistance & biocompatibility
  - Lowest modulus of elasticity among the 3 commonly used metals; still significantly greater than that of bone
  - Offers the least interference with magnetic resonance imaging & CT scan
- **Bioresorbable plating systems**
  - Considered semi-rigid fixation
  - Applications: Craniofacial procedures, cranial flap fixation, upper face and mid face fractures, some comminuted fractures
  - Some resorbable systems offer mandible fixation options: sagittal split osteotomy screws and mandible fracture plates
  - Contraindications: Infection, comprised blood supply, poor bone quality or quantity, mandibular bridging

Material types & biocompatibility

- **Biocompatibility:**
  - The body's tissues will tolerate the implant material indefinitely.
- **Corrosion:**
  - Stainless steel, vitallium, and titanium implants have all shown to resist corrosion over time
  - When different metals are in contact, the differing galvanic potentials in the tissue environment will lead to galvanic corrosion. Implants from different plating systems should not be used together.
- **Hypersensitivity/Toxicity**
  - Metal ions are released in small amounts from alloys. Elevations in local tissue concentrations show these increases to be brief only during the postoperative period.
  - Hypersensitivity may occur to metals containing nickel, cobalt, and chromium when implanted in large volumes.
  - Only pure titanium has never elicited a human hypersensitivity reaction
- **Carcinogenicity**
  - No direct cause and effect relationship has been proven.
- **Osseointegration**
  - Osseointegration is the development of a biological bond between the metal implant and the surrounding bone.
  - Osteocytes grow up to & adhere to the metal surface. It occurs inconsistently and with only pure titanium implants.

Section II:

Rigid Fixation

Uses of rigid fixation

- Reconstructive Surgery
- Fracture Treatment
- Orthognathic Surgery

Goals of rigid fixation

- Reduction=union of bone segments
- Complete restoration of original or designed bone form & function
- Early mobilization=how long does the patient need to be in MMF?

Principles of rigid fixation

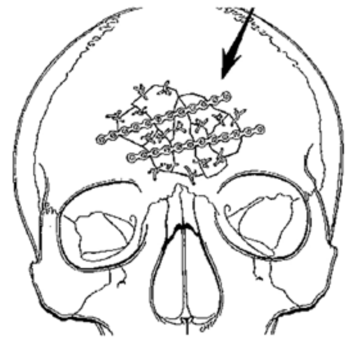
- A screw of proper strength & design will hold in bone over time
- A properly designed & positioned rigid plate will impart its strength to a fractured or osteotomized bone when it is properly fixed to that bone with screws
- Devices can be fixed to fractured & osteotomized bones so that the bones remain fixed together despite full loading in function
- Additional fixation points generally yield a stronger fixation
- If the rigid fixation device is strong enough & if enough fixation points are used, a bone defect can be bridged with the fixation device so that the remaining segments can support the functional load
- Plate screwed across the fracture will not impart stability unless fixation device is appropriate for particular anatomical and physiological need
- Number of fixation points is adequate
- Strict adherence to biomechanical principles

Potential benefits of rigid fixation

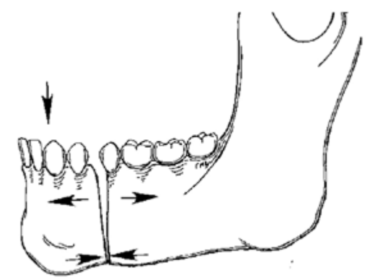
- Direct bone healing without callus formation
- Early or immediate post-operative function
- Improved patient comfort and convenience
- Improved post-operative nutrition
- Improved stabilization of osteotomy segments at the time of surgery
- Allows elimination of MMF when this is required due to other medical problems
- Allows for improved management of uncooperative patients

Biomechanics

- The strength of a repair must be adequate to overcome any forces that will act on the repaired bone during post operative function

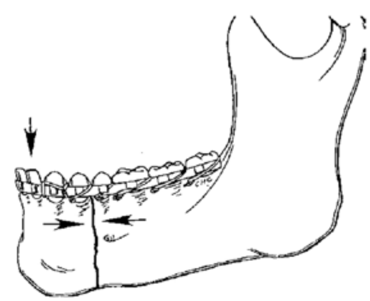


- No force
  - Minimal fixation is needed
  - Example is the anterior wall of the frontal sinus
  - Repair with microplates with a minimum number of fixation points

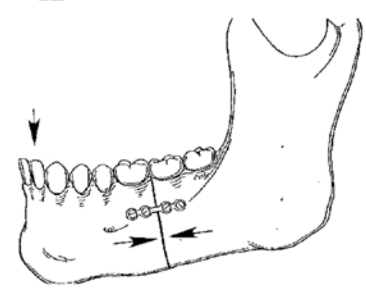


- Distracting forces
  - Forces pull the fragments apart
  - Example is the alveolar area of the mandible
  - In many cases, when compressive forces occur across one portion of the fracture, another portion will be distracted.

- Tension banding: a device is used to overcome the tractional forces, the compressive forces that occur during function will tend to be distributed across the entire area, leading to healing.

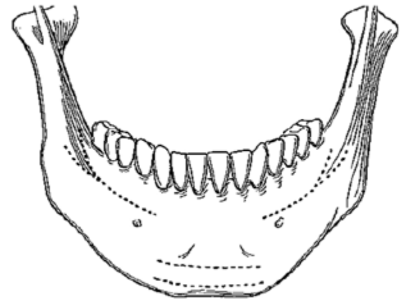


- Tension band/traction wire
  - Wire used to hold the traction area together: arch bars



- Tension band/miniplate approach
  - Miniplate placed along the tension area, holding the traction area together at rest while allowing the compressive forces that occurnaturally below to be distributed across the entire fracture
  - When forces vary during function (angle region) or torsional forces act on the area (symphyseal region) then two stability to be achieved

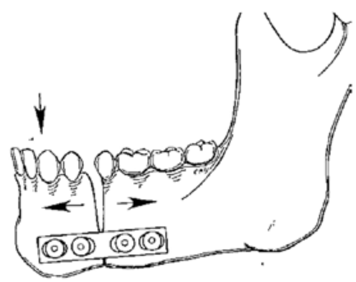
Biomechanics (cont.)



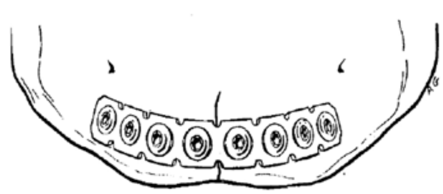
- Champy's lines of osteosynthesis
  - Miniplate is applied with monocortical screws 1.5-2 crown heights below the gingival margin to avoid injury to tooth roots and the inferior alveolar nerve

Compressive forces

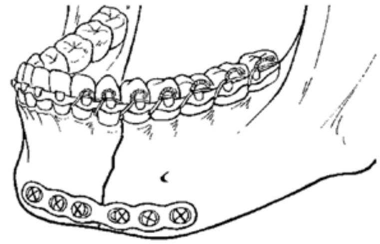
- Forces compress the fragments together
- Example is the inferior mandibular body or the maxilla with a Le Fort I fracture or osteotomy
- Fixation must be strong enough to hold the bones in the proper position during healing so they don't shift from shearing or overcompression; therefore miniplates work well in the maxilla
- Compression plate
  - Compression plating at the inferior border without tension banding (arch bars or a miniplate) will result in distraction along the traction area
  - Compression plate may be placed above the inferior border of the mandible in the symphyseal region or in patients with an edentulous mandible. There is no need for a tension band in this circumstance.



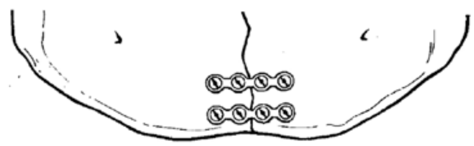
- Long reconstruction plate
  - Long, heavy reconstruction plate with multiple fixation points (at least 4 on each side of the fracture) will prevent mobility in all areas of the bone and provide adequate stabilization for healing (even without tension banding)



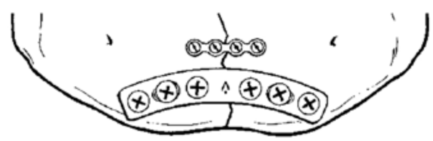
Torsional forces



- Forces tend to rotate the fragments
- Example is the mandibular symphyseal region
- Long Fracture Plate
    - Use of a mandibular fracture plate fragment will support a symphyseal fracture

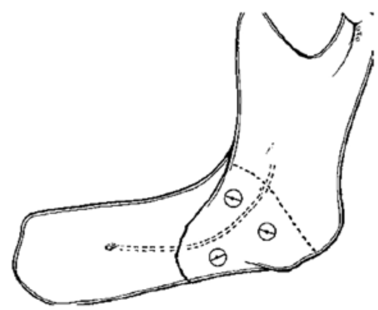


- Two miniplates
    - Upper miniplate overcomes distracting forces and the second miniplate overcomes torsional forces



- Miniplate tension and with a fracture plate
    - Miniplate overcomes distracting forces and the fracture plate overcomes torsional forces
- An arch bar tension band and a fracture plate
    - Arch bar overcomes distracting forces and the fracture plate overcomes torsional forces

Overlapping fragments



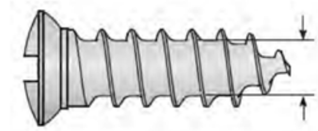
- Seen in oblique fractures or in the placement of bone grafts
- Stabilized by lag screws
- Multiple lag screws overcome shearing, torsional, and rotational forces

Section III:

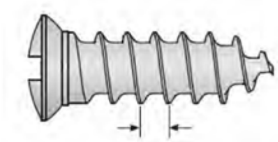
Products used for rigid fixation

Anatomy of a screw

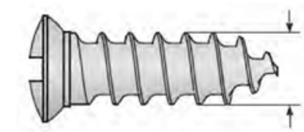
- Core diameter
  - Diameter of the shaft of the screw



- Thread design & pitch
  - Thread pitch determines the distance of the purchase of the screw into the bone with each 360 degree turn

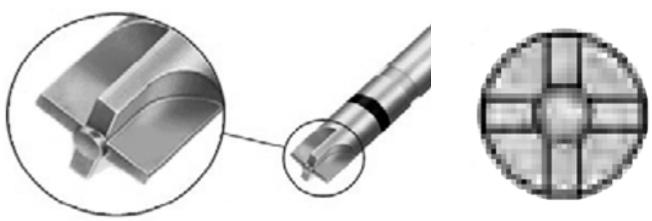


- Screw diameter
  - Diameter of the screw from thread to thread



- Tip design
  - Self-tapping: Blunt tip, requires pilot hole drilling
  - Self-drilling: Sharp tip, does not require pilot hole drilling

- Head designs
  - Cross-Fit (cruciform)
  - Square-Fit
  - Hex-Fit
  - Cross-Pin Friction-Fit (cruciform with centering pin)

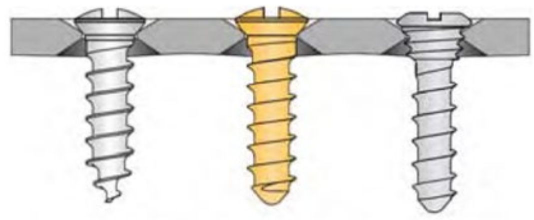


Types of screws

- Screw facts
  - A screw develops grip in the cortical bone never in the spongiosa (cancellous bone)
  - Mandible cortical distance is approximately 3-5mm
  - Mandible bicortical screws vary in length from 9-20mm

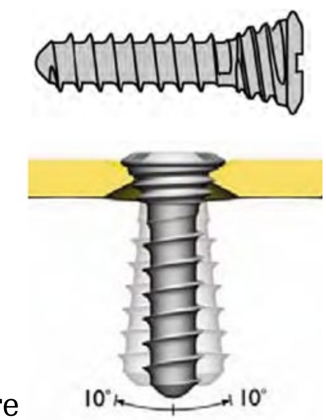
Types of screws (cont.)

- **Self-drilling screws**
  - Sharp tip & threads
  - No pilot hole drilling required
  - Downward force required to start the purchase of the screw in the bone
  - Not the ideal choice for comminuted bone fragments or very dense bone



Self-Drilling (silver) | Self-Tapping (gold) | Locking Screw (grey)

- **Self-tapping or bone screws**
  - Pilot hole drilling is required before screw insertion because the tip of the screw is blunt
  - Threads are sharp enough for the screw to tap itself, therefore no tapping is required



- **Locking screws**
  - Threads on the underside of the screw head engage the circular lip within the hole of the plate
  - One-step locking screw with a locking capability up to 10 degrees of angulation in any direction
    - Do not have to be perfectly perpendicular to the bone when inserting the screw
    - Ideal for difficult access to specific anatomical areas
  - Creates a more rigid plate screw construct
    - Decreases the possibility of infections or implant failure caused when screws loosen
    - Acts as an internal-external dual fixation. The threads on the underside of the screw head are engaged into the lip of the plate and the threads around the core of the screw are engaged in the bone
  - Allows for passive contour of the plate
    - Ideal for specific anatomical areas where perfect contour of the plate is difficult
    - Since the threads on the underside of the screw head engage in the plate, the screw insertion will not pull the bone up to the plate which would cause a loss of reduction
  - No bending inserts required for this locking technology
  - Insert with the use of a drill guide and drill guide handle
  - 1.7mm Locking Screws must only be used with 1.7mm Locking Plates

Types of screws (cont.)

- **Emergency screws**
  - Screw used when a hole in the bone strips
  - Screw of a greater diameter than the original screw is used
    - Example: 1.4mm emergency screw for a 1.2mm screw
  - If a screw placed in a hole continues to turn and won't tighten, it should be removed. Loose screws provide no stabilization and can be a source of infection if not removed.
  - These screws are color coded purple in the 1/2/1.5/1.7/2.0MP modules
  - In the Mandible Fracture & Reconstruction modules, the emergency screw size is the next diameter up.
    - Example: The emergency for a 2.0mm screw is 2.3mm; the emergency for a 2.3mm screw is 2.7mm

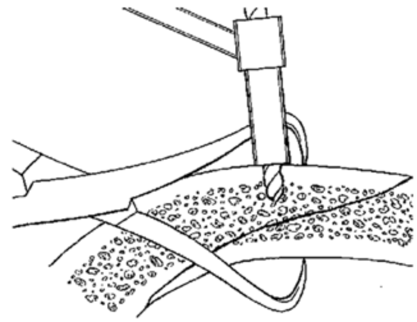
- **Lag screws**
  - Key to the proper repair of oblique fractures & overlapping bone fragments (including bone grafts) is the recognition that compression can only be achieved pressing the overlapping surfaces together, not by trying to bring the fragments together along the axis of the bone.
  - Axial compression is only effective when the bone edges abut against each other. When they overlap, axial compression results in distraction. That is why overlapping fragments are compressed together using a lag screw technique
  - The lag screw is a screw placed so that the thread will not catch in the first fragment and it catches and tightens securely in the second fragment. As the screw is tightened compression is achieved.
  - 2-3 lag screws are often used to complete the stabilization of the fracture fragments

Types of screws (cont.)

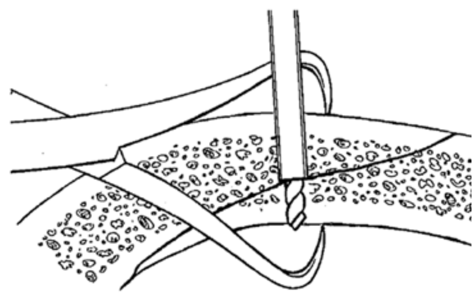
- **Lag screw technique**

  Step 1: Fracture is reduced using a bone-holding clamp or reduction forceps.

  Step 2: Using the overdrill bit and drill guide, drill to the fracture line. The overdrill is the size of the screw thread to thread rather than the size of the shaft of the screw so that the threads will not catch in the bone. Make sure the hole is drilled close to perpendicular to the fracture line.



  Step 3: Place pilot drill guide into overdrill hole. Using the pilot drill bit, drill past the fracture line into the distal cortex. The pilot drill is the size of the shaft of the screw so that the screw threads will purchase in the distal fragment.



  Step 4: Measure the depth to make sure that both fragments are caught when inserting the screw

  Step 5: Tap. The tap will glide through the first fragment

  Step 6: Insert screw. The screw will glide through the first cortex and the threads should catch in the second cortex. Tightening of the screw will compress the bone fragments together therefore stabilizing the fracture.

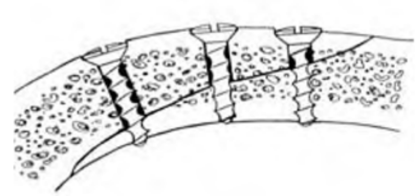
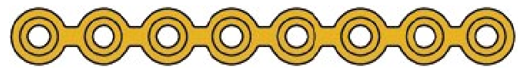
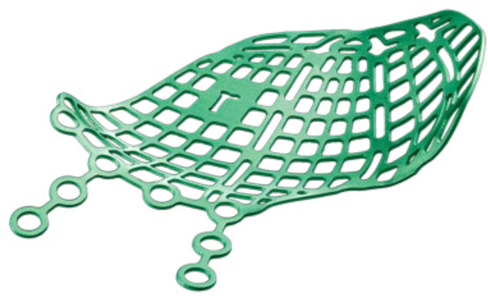


Plate options

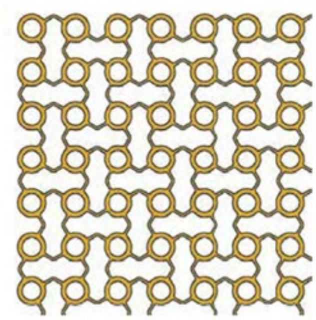
- **Upperface plates: 1.2mm screw system**
  - Low Profile=.5mm profile=Color is Blue
  - Standard=.6mm profile=Color is Gold
  - Module & instrumentation is color coded



- **Orbital floor plate**
  - 3 sizes: isolated, basic, complex
  - Complex size has an "M" on the plate to represent medial to assist in the placement of the plate
  - Low profile=.3mm profile=Color is Blue
  - Standard=.4mm profile=Color is Gold
  - Grey templates available
  - Fixated with 1.2mm screws



- **Dynamic mesh**
  - Low profile=.3mm profile=Color is Blue
  - Standard=.6mm profile=Color is Gold
  - Two options for screw sizes:
  - One mesh will accommodate 1.0-1.4mm screws
  - One mesh will accommodate 1.5-2.0mm screws



- **Micro mesh**
  - Can insert screws anywhere in this piece of mesh, there are no designated screw holes
  - Low profile=.1mm profile=Color is Blue
  - Standard=.2mm profile=Color is Gold

Plate options (cont.)

- **Midface miniplates: 1.7mm & 2.0mm mini plates**
  - Low profile=.5mm profile=color is blue
  - Standard=.6mm profile=color is gold

  - Graduated stability plates=.6mm=Ccolor is gold with “G” laser etched on top
    - Offer a progressive level of fixation required as the LeFort I advancement increases
    - This built in progressive stability is a unique feature that allows for optimal fixation
    - Available in L or Z shaped plates
    - The plates with a shorter bar are used for limited advancements and are more malleable for ease of use
    - The plates with a longer bar are used for extensive advancements and provide the increased level of rigidity required for stable fixation

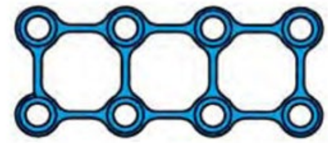
  - Locking=0.8mm profile=color is grey

  - 2.0mm Wurzburg=1.0mm profile=color is green= wider spacing between holes

  - 2.0mm Steinhauser=0.8mm profile=color is green= narrower spacing between holes

Plate offerings (cont.)

- **Mandible miniplates**
  - Low profile=1.0mm=color is blue
  - Straight plate & 3-Dimensional plate options
    - 3-D plates designed to add increased strength to the plate
  - Reversible
  - Use with 2.0mm, 2.3mm, or 2.7mm self-tapping or locking screws



- **Mandible fracture plates**
  - Standard=1.5mm profile=color is gold
    - Laser etching to aid in top/bottom orientation: Laser etching should be facing up.
  - Templates available for ease of contouring
  - Use with 2.0mm, 2.3mm, or 2.7mm self-tapping or locking screws

- **Orthognathic plates**
  - LeFort I pre-bent plates
    - 0.9mm profile=color is gold
  - BSSO plates
    - 1.0mm profile=color is gold
    - Use with 2.0mm or 2.3mm self-tapping or locking screws
  - Pre-bent chin plates
    - 0.6mm profile=color is gold
    - Use with 1.7mm screws

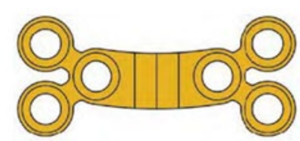


Plate offerings (cont.)

- **Mandible reconstruction plates**
  - Plate designed to be long & strong enough to bridge defects of the mandible, areas of severe comminution, or atrophy of the bone
  - At least 3-4 screws should be placed into healthy bone on either side of the defect

- **Primary reconstruction plate**
  - Used in conjunction with a bone graft or to repair a comminuted mandible fracture
  - 1.5, 2.0, 2.4, & 2.5mm profile = Color is Gold
  - Laser etching on top of the plate to aid in top bottom orientation
  - Templates available for ease of contouring
  - Can be used with 2.0mm, 2.3mm, or 2.7mm locking or bone screws

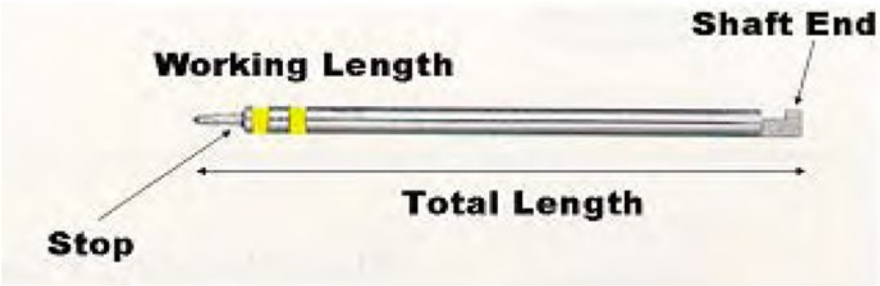
- **Secondary reconstruction plate**
  - Used to bridge mandibular defect sites
  - 2.8mm profile=Color is Silver
  - Laser etching on top of plate to aid in top bottom orientation
  - Templates available for ease of contouring
  - Can be used with 2.0mm, 2.3mm, or 2.7mm locking or bone screws

- **Temporary condylar head prosthesis**
  - Approved for use up to 2 years post-op

Front Back

Plate offerings (cont.)

- **Drill bit anatomy**
  - Diameter of the shaft is close to the core diameter of the screw
  - Color-coded bands
    - Color bands on the drill bit correspond with the diameter screw used (yellow bands for the 1.2mm system)
- Working length
  - The length of the cutting flutes that enter the bone
- Stop
  - For monocortical screw fixation
  - Prevents the drill bit from drilling too deep



- Total length
  - The total length of the drill bit from the tip of the working end to the shaft end
- Shaft ends
  - Stryker J Latch End
    - Used in most OR drills (Stryker, Hall)
  - Dental Shaft End
    - Used in some office based drill systems
  - AO Shaft End
    - Used with Synthes drills

Section IV:

Rigid fixation sequence

Rigid fixation sequence

1. Reduce the fracture

- There are many reduction instrument options available
- Bone repositioning pin: used to reduce the zygoma through a stab incision made over the zygoma

- Mandible reduction forceps
- Bone reduction forceps

2. Plate selection

- Adequately bridge the defect
- Provide stable fixation
- Consider the shape of the anatomical region

3. Plate contoured to the surface of the reduced bone segments

- Needle nose benders
- 1.2/1.7 upper face/mid face benders
  - 90 degree bend feature
- 3 prong bender
  - Used for in-plane bending

- Mandible Fracture Bender/Cutters
  - Use with 2.0/2.3mm Mandible plates
  - Designated Left and Right. The cut window is on the right instrument.

- Mandible Recon Bender/Cutters
  - Use with 2.0/2.3mm Reconstruction plates
  - Designated Left and Right. The cut window is on the right instrument.

Rigid fixation sequence (cont.)

- Mandible Recon Roller Bender
  - Use with 2.0/2.3mm Reconstruction plates
  - Both in-plane and out-of-plane be nding capabilities

4. Plate positioning

- Positioning can be assisted with different instrument options
- Pickle-fork for 1.2/1.7 systems
- Locking forceps for all system sizes

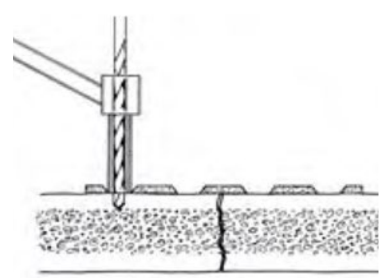
- Plate holding cap to assist in holding the plate on the mandible when using the trocar system transbucally

- Plate-to-bone forceps used for positioning of mandible reconstruction plates

5. Screw selection: self-drilling, self-tapping, or locking

6. Pilot hole drilling

- Use corresponding diameter drill bit for the screw diameter & length selected
- Drill hole depth should match or exceed the length of the screw chosen
- Always start drilling the hole closest to the fracture line (on either side of the fracture)
- Your second hole should be on the opposite side of the fracture line
- Use of a drill guide when drilling for a bicortical screw or when drilling through the trocar handle for transbuccal approach
  - Protects surrounding soft tissue
  - Prevents drill bit whip
  - Guides the drill in perpendicular motion in and out of the bone
- Always operate drills at the minimum speed possible. Stryker TPS Drill defaults to 40,000 RPM. This is too high of a speed for maxillofacial applications.



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Rigid fixation sequence

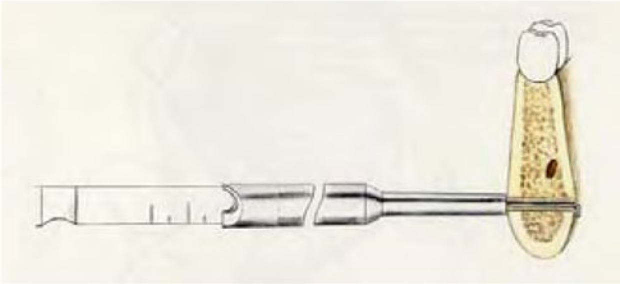
Rigid fixation sequence (cont.)

6. Pilot hole drilling (cont.)

- Turn the drill speed down to below 20,000 RPM.
- Always use irrigation when drilling to prevent necrosis of the bone
- Always hold drill perpendicular to the screw hole position

7. Use of a depth gauge to measure the length of screw required

- Used most often when inserting bicortical screws
- The foot of the depth gauge is extended and turned slightly until it catches the distal or lingual cortex
- Determine the screw length using the depth gauge markings
- Use the next larger screw size should the depth measurement fall between markings



Rigid fixation sequence (cont.)

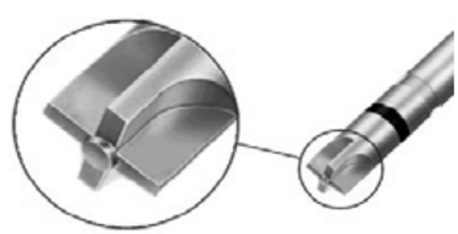
8. Loading the Screw

- Choice of screwdriver handles
  - Ratchet

  - Rigid/Revolving

  - 2 finger turn

- Modules have recessed screw holes for ease of loading and reduced trampoline effect
- Point screwdriver blade down onto the screw; perpendicular to the module
- Turn the blade until you see the screw turning with you
- Put downward force onto the screw to engage the friction-fit cross-pin design
  - There is a pin on the end of the screwdriver blade which engages in the center of the cruciform head design



- Pull the screw straight out of the hole to avoid hitting the sides of the screw hole

Rigid fixation sequence (cont.)

9. Inserting the screw

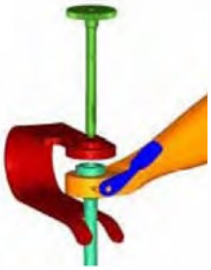
- Always start drilling the hole closest to the fracture line (on either side of the fracture)
- Your second screw should be on the opposite side of the fracture line
- If the screw fails to gain a secure grip in the bone, an emergency screw should be used. You need a larger diameter screw to fit into the larger hole.
- To prevent rotational movement of the bone segments, 2 or 3 screws should be placed on either side of the fracture site.
- To disengage the screw from the screwdriver blade, simply rock the screwdriver blade off axis in any direction.

10. Using the trocar system when going transbuccal

- Pull out the trocar handle
- Select your choice of check retractor
  - Horse-shoe shaped cheek retractor
  - Variable cheek retractor
- Attach your cheek retractor to the trocar handle

- Pull out the trocar or obturator to punch through the stab incision in the cheek
- Place the trocar through the trocar handle and punch through the stab incision in the cheek

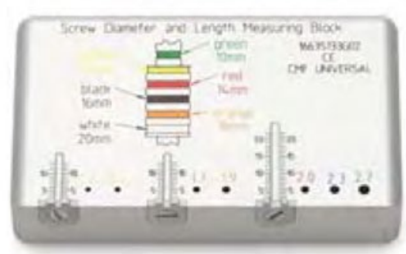
- Remove the trocar from the trocar handle
- Position the plate where desired



Rigid fixation sequence (cont.)

- Select a drill guide
    - Insert the drill guide into the trocar handle, turn it 45 degrees to lock it in place
- Select a drill bit
    - Choose a longer total length drill bit that will be long enough to drill through the trocar handle and into the bone. Select the drill bit based on the diameter of the screw you are planning to use. If you want to use a 2.3mm diameter screw, select the blue banded long total length drill bit.
- This drill bit does have laser etchings 5mm apart from one another to help determine the length of screw needed
- Rainbow Colored Drill Bit
    - Eliminates the need for both a drill guide and a depth gauge
    - It has a wider shaft, eliminating the need for a drill guide
    - The rainbow color bands represent the length screw that should be chosen

- When drilling, pay attention to the color bands. The last color band you see when you engage the lingual cortex with the drill is the color representing the depth of the screw to be used. Look at the corresponding screw measuring block to tell you what length screw should be used.
- Insert Screw
- Screw insertion is done through the trocar handle



Contour & application: Mid-Face locking plate

1. Use benders to contour locking plates.
   - Benders include plate pockets with hole-pegs to reduce hole deformation.

2. Cut plate with right handle (R) in area labeled cut. Slide the plate into the cutting area. Cut will take place within the window.

3. Only insert first screw about 75% of the way, then drill the hole for the second screw and insert second screw 100% until locked into the plate. Finish tightening the first screw, then proceed with the other screws.

Contour & application: Mandible fracture plate

1. Use benders to contour the fracture plate. Benders include plate pockets to reduce hole deformation.

2. Cut Fracture Plate with the right handle (R) in the area labeled Cut. Slide the plate through the cutter from left to right. Cut will take place within the window.

3. Insert the drill guide through trocar and drill hole..

4. Measure desired screw length using a depth gauge.

5. Insert screw and repeat process for each screw until fracture fixation is complete.

Contour & application: Mandible primary reconstruction plate

1. Expose the defect and select the appropriate template.
   - Recommended screw placement for each segment includes: Neutral bone screws (4 each); Locking screws (3 each) of either 2.0 or 2.3mm diameter

2. Cut Primary Reconstruction plate with the right handle (R) in the area labeled cut. Slide the plate through the cutter from left to right. Cut will take place within the window.

3. Contour Primary Reconstruction Plate to match template using benders. Benders include plate pockets to reduce hole deformation.

4. Insert drill guide through trocar and drill hole.

5. Measure desired screw length using a depth gauge.

6. Once plate is in place, remove screws and plate. After mandibular resection, replace “pre-bent” plate and screws. Reco mmend using temporary recon screwholder.

Contour & application: Mandible secondary reconstruction plate

1. Expose the defect and select appropriate template.

2. To cut, lock plate in left handle (L) labeled cut. Place cutting mechanism in right handle (R) flush alongside the plate recess in the left handle. Slide (R) handle up until plate is seated within locking mechanism. Once plate is fully seated in the cutting mechanism, rotate counterclockwise to shear plate.

3. Contour Reconstruction Plate to match template using benders. Benders include plate pockets to reduce the amount of hole deformation. Roller benders can be used for out-of-plane bending.

4. Insert drill guide through trocar and drill hole.

5. Measure desired screw length using a depth gauge.

6. Once plate is in place, remove screws and plate. After mandibular resection, replace "pre-bent" plate and screws. Recommend using temporary recon screw holder.

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