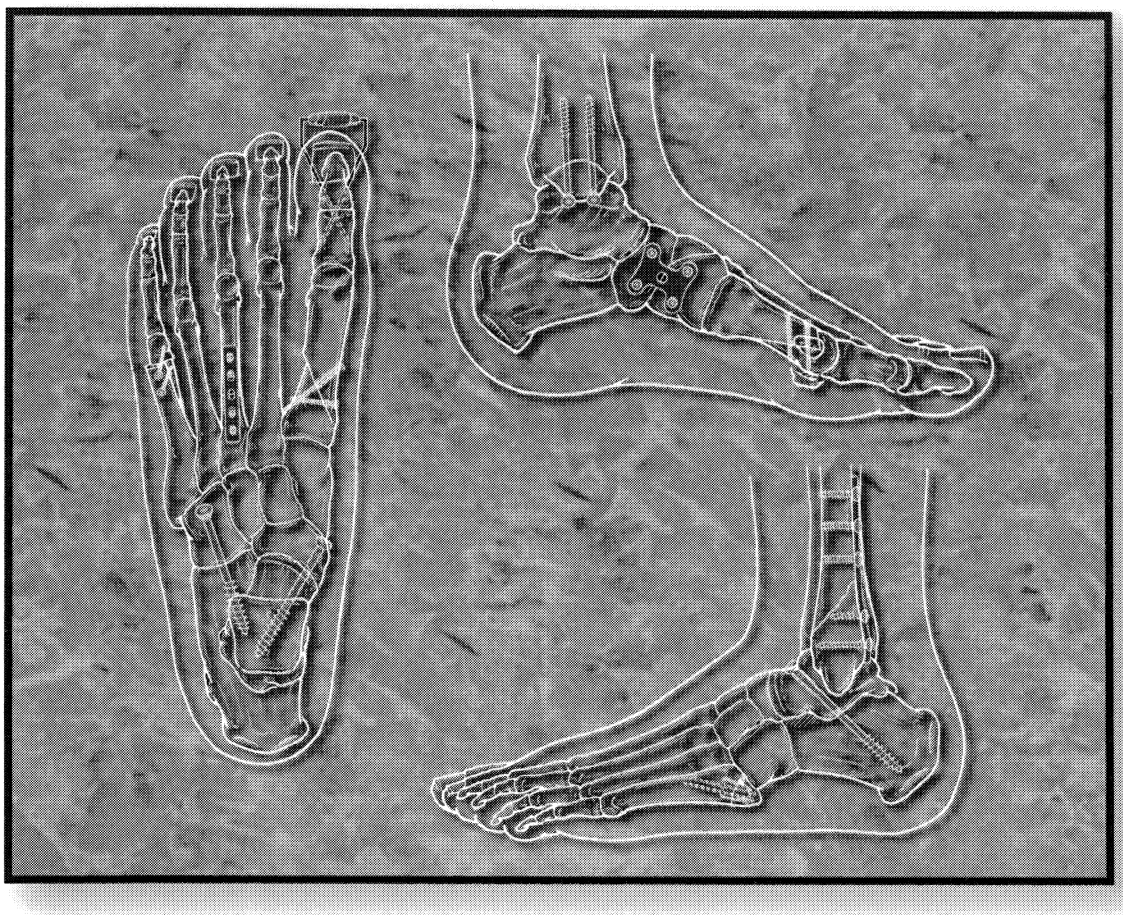
Basic Podiatric Course

INTERNAL FIXATION OF THE FOOT & ANKLE



INSTRUCTIONAL COURSE WORKBOOK

Editors
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Basic Podiatric Course
Internal Fixation of the Foot and Ankle
INSTRUCTIONAL COURSE WORKBOOK

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The purpose of this workbook is to present principles and techniques of internal fixation utilized in commonly performed procedures of foot and ankle surgery including reconstructive techniques, joint fusion and repair of common fractures.

The techniques and use of implants illustrated are intended as guides to demonstrate fundamental skills and are not intended to serve as the definitive technique for any specific procedure or condition.

THIS TEXT IS DEDICATED TO THE MEMORY OF GERARD VINCENT YU, DPM.

Gerard was the consumate physician, teacher, husband, father and friend.
We will miss him dearly, but the joy of his memory will live in our hearts forever.
The standards that he set will always be what we strive to attain.

GERARD V. YU (1954 - 2005)

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I. NON-SCREW FIXATION TECHNIQUES

I.A. FUNDAMENTALS OF K-WIRE, STEINMANN PIN AND CERCLAGE WIRE FIXATION

(including principles of intramedullary splintage, cerclage wire techniques, tension band principles, tension band wire techniques)

PURPOSE:

- Principles and Techniques for use of K-wires, Steinmann pins, cerclage wire

POINTS OF INSTRUCTION:

Techniques:

Intramedullary Splintage
Crossed K-wire fixation ***(fig. A)***
Splintage / Tension band wire combinations ***(fig. B)***
Intra Osseous Loop (IOL) wire fixation ***(fig. C)***

K-wires:

Tip: trochar
Shaft: smooth, threaded
Sizes: 0.035 in. (0.9 mm)
0.045 in. (1.1 mm)
0.054 in. (1.4 mm)
0.062 in. (1.6 mm)

Steinmann pins:

Tip: blade, trochar
Shaft: smooth
Sizes: 5/64 in. (1.9 mm)
3/32 in. (2.3 mm)
7/64 in. (2.7 mm)
1/8 in. (3.1 mm)
9/64 in. (3.5 mm)
5/32 in. (3.9 mm)
3/16 in. (4.7 mm)

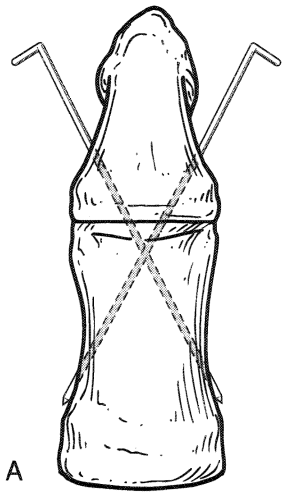
** ***AO wire bender*** - specialized cannulated bending rod used for bending pins and wires

Cerclage / Tension band wire: ***(fig. C)***

AO / 1.25 mm, 1.0 mm, 0.8 mm

US / 18, 20, 22, 24, 26, 28*, 30 ga.

malleability, handling characteristics
*twisted double strands of 28 ga. wire gives additional strength, maintains malleability and more resistance of fracture at the knot
twisting technique: *maintain tension while twisting and securing knot to avoid kinking*



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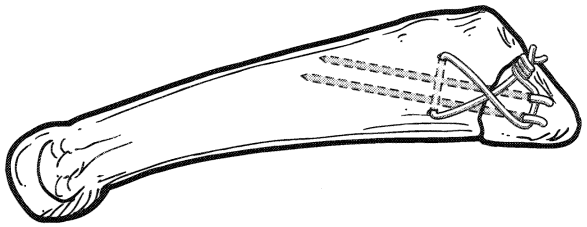

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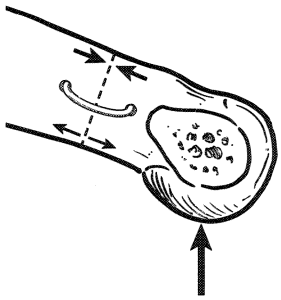


I. NON-SCREW FIXATION TECHNIQUES

I.B. "CROSSED K-WIRE" TECHNIQUE (HALLUX IPJ FUSION)

PURPOSE:

- demonstrate principles and technique of "crossed K-wire fixation"

- **1st pin** / single pin captures alignment and apposition / **DOES NOT** prevent rotation or distraction

- **2nd pin**
  - inserted through the unstable fragment into the stable fragment
  - captures apposition at the contact surface
  - prevents rotation of the unstable fragment around the 1st pin
  - prevents distraction of the unstable fragment along the 1st pin

POINTS OF INSTRUCTION:

- Cut interphalangeal joint ***(fig. A)***

- **Retrograde technique**
  - Identify the points of insertion in the articular surface of the distal phalanx ***(fig. A)***
  - Stagger penetration points medial - lateral, stack dorsal - plantar ***(fig. A)***
    to decrease potential for rotation and prevent collision of the pins as they cross the joint
  - Direct the pins distally so that they can be retrograded proximally,
    so they will cross proximal to the joint within the proximal phalanx ***(fig. C)***

- **1st pin insertion**, in distal phalanx, proximal to distal, out the medial aspect of distal phalanx. ***(fig. A)***

- **2nd pin** inserted out through the lateral aspect of the distal phalanx. ***(fig. A)***

- Pull the pins through so that the tips are just beneath the articular surface of the distal phalanx. ***(fig. B)***

- Reduce the joint, then retrograde the pins into the proximal phalanx ***(fig. B)***

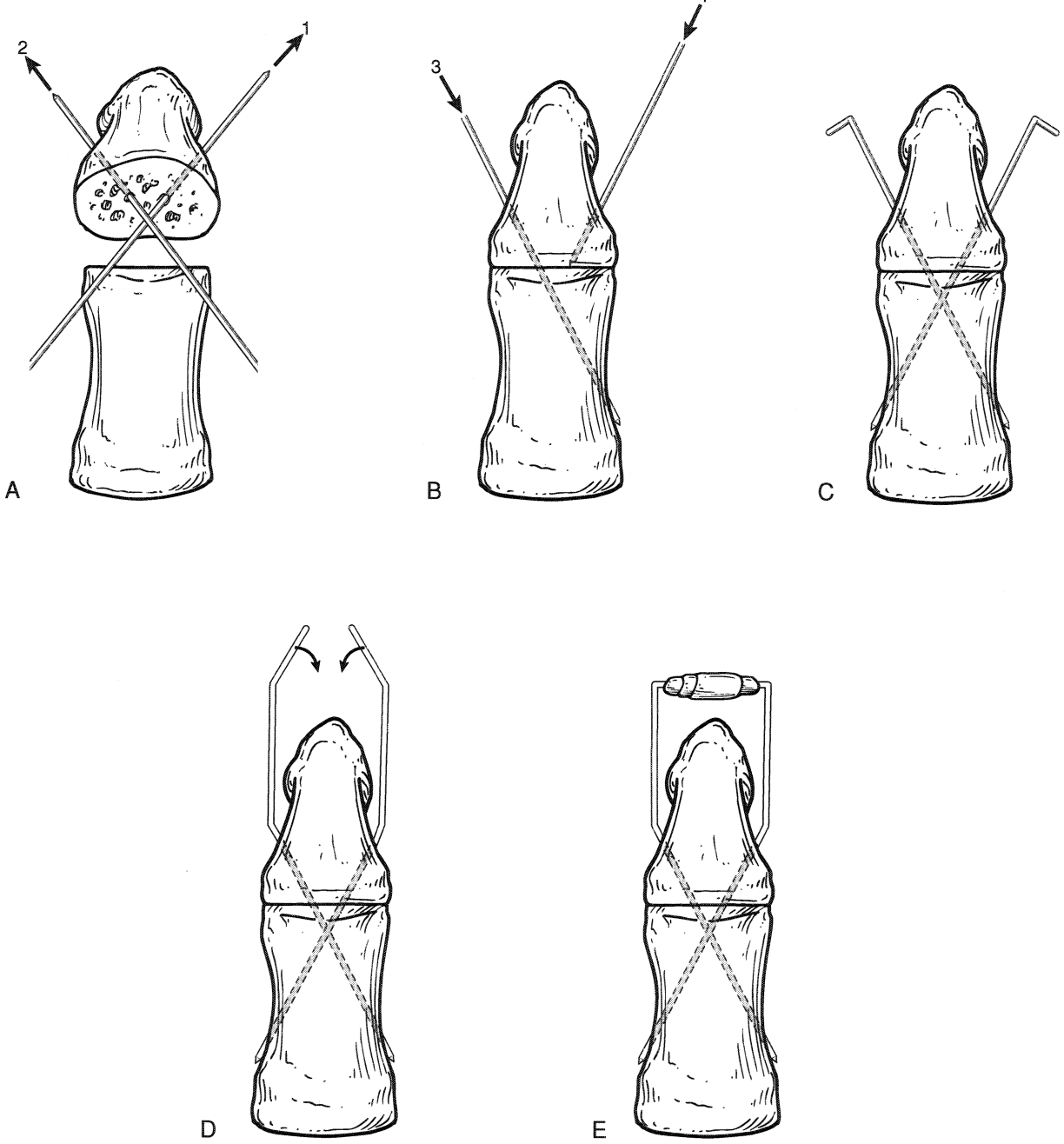
- Drive the pins through the unstable fragment of the distal phalanx into stable fragment
  of the proximal phalanx. ***(fig. B)***

- Angle the pins so that they will cross within the body of the proximal phalanx.

- Penetrate the medial and lateral cortices of the proximal phalanx ***(fig. B,C)***

- **2nd pin blocks rotation and axial motion on the 1st pin,**
  the 2nd pin captures apposition, prevents rotation and distraction

- Secure pins with **"bucket handle" technique** to lock the pins together ***(fig. D,E)***
  **this technique prevents accidental pull out and provides an interlocked and more stable fixation*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I. NON-SCREW FIXATION TECHNIQUES

I.C.1. "LOCK PIN" TECHNIQUE (AUSTIN)

*AXIS GUIDE AND OSTEOTOMY TECHNIQUE *(for chevron osteotomies of the 1st metatarsal)*

PURPOSE:

- demonstrate axis guide concept / osteotomy technique

POINTS OF INSTRUCTION:

Axis guide

- lengthen or shorten 1st metatarsal with lateral shift of the capital fragment ***(fig. B)***
- plantar or dorsal displacement of the metatarsal head with lateral shift ***(fig. C)***
- do not place the apex or entry point for axis pin too close to the articular surface,
* medial point of penetration is placed slightly above center if using a plantarflexion angle of the axis pin ***(fig. A)***

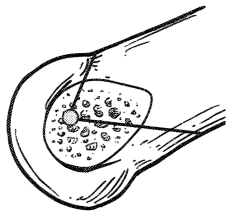
Osteotomy technique

- determine angle of plantar and dorsal arms of the osteotomy
- plantar arm dictates the angle of insertion for the fixation device
* fixation device is oriented approximately perpendicular to the plantar arm of the osteotomy
- dorsal cut tends to be more vertical to create more surface area of cortical bone for insertion of the fixation device
- keep the saw blade in line with the pin while cutting the osteotomies to ensure that the osteotomy planes converge along the axis pin
- osteotomies contact the axis pin at the medial entrance and lateral exit of the bone
- accurate alignment of the osteotomies creates a stable contact seat or apposition of the osteotomy with lateral displacement of the metatarsal head on the proximal segment of the metatarsal

Tips for use of power instrumentation for metatarsal osteotomy

- two hand technique
- score cortex to identify angle of the osteotomies
- initial cut of the plantar arm, focus on the plantar cortex of the bone, keeping blade in line with the pin
- then rotate saw blade and cut to the axis pin, keeping blade in line with the pin
- exit through the lateral cortex of the bone
- cut dorsal arm of the osteotomy

A



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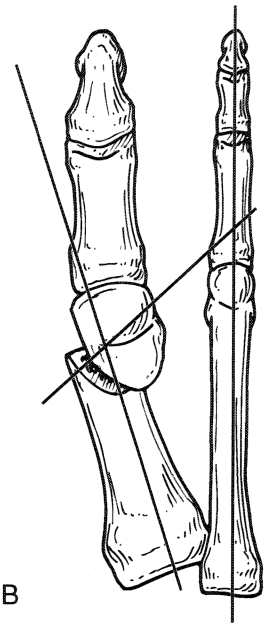
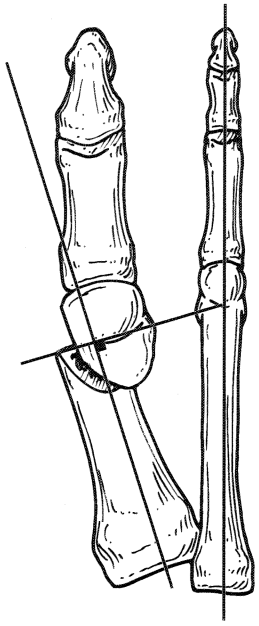
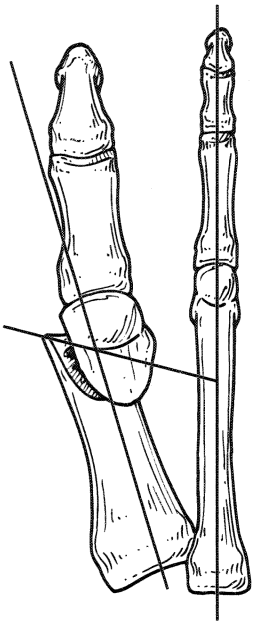


Lengthening

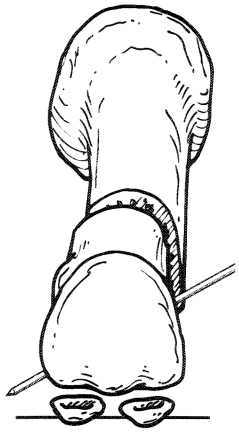


Neutral

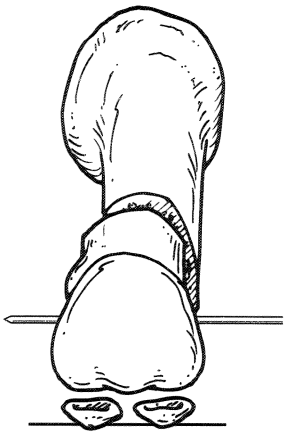


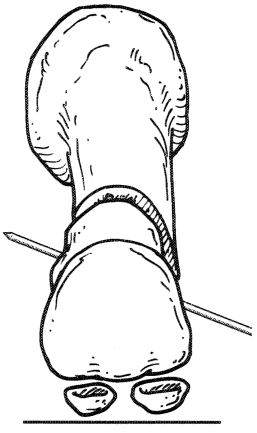
Shortening

C



Plantarflex





Dorsiflex

I. NON-SCREW FIXATION TECHNIQUES

I.C.2. G.V. YU "LOCK PIN" TECHNIQUE (AUSTIN)

(bend and cut "outside" of the bone)

PURPOSE:

- demonstrate locking pin fixation technique with placement of a temporary fixation pin followed by measurement, bending and cutting of the "final" fixation outside of the bone
- this technique is used to avoid displacement or fracture while bending the fixation pin

POINTS OF INSTRUCTION:

Preliminary Wire Insertion (0.062 in. / 1.6 mm K-wire) ***(fig. A.)***

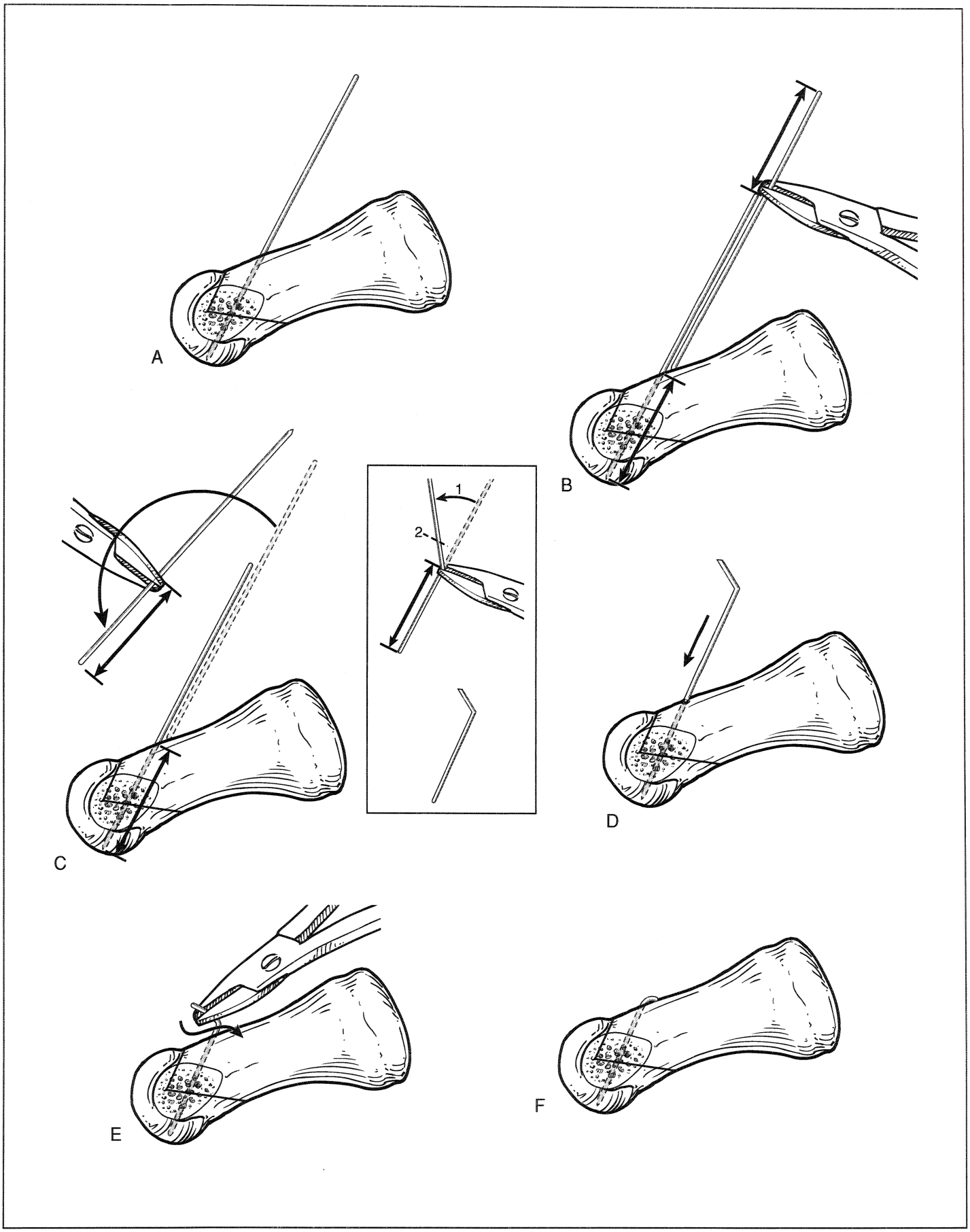
- insert the pin in the dorsal (proximal) metatarsal segment
- not too close to the osteotomy to prevent fracture into the osteotomy with manipulation of the pin
- mid-line or slightly lateral on the metatarsal to give adequate space for resection of the medial overhang
- orient the pin approximately perpendicular to the plantar arm of the osteotomy
- visualize penetration of the pin through the plantar articular surface of metatarsal head, then withdraw the tip of the pin just inside the subchondral bone

"Lock Pin" / Fabrication ***(fig. B, C)***

- measure the appropriate length of the "lock pin" by laying a second K-wire alongside the inserted wire
- grasp the extended portion of the second pin with a needle nose pliers to mark the exact length of pin that will be inserted into the bone
- bend the long portion of the pin approximately 30°
- cut the pin so that sharp point (underside of the pin) will engage cortex of bone

Insertion of the "Lock Pin" ***(fig. D, E, F)***

- remove the initial K-wire
- insert the "lock pin" and rotate the pin 180° so that external portion of the pin "swages" against the dorsal cortex, capturing the bend and locking the pin in place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I. NON-SCREW FIXATION TECHNIQUES

I.C.3. "IN SITU" LOCK PIN TECHNIQUE (AUSTIN)

PURPOSE:

- demonstrate locking pin fixation technique by bending the initial fixation pin in the bone

POINTS OF INSTRUCTION:

Preliminary Wire Insertion (0.062 in. / 1.6 mm K-wire) ***(fig. A.)***

- insert the pin in the dorsal (proximal) metatarsal segment
- not too close to the osteotomy to prevent fracture into the osteotomy with manipulation of the pin
- mid-line or slightly lateral on the metatarsal to give adequate space for resection of the medial overhang

- orient the pin approximately perpendicular to plantar arm of osteotomy ***(fig. A)***

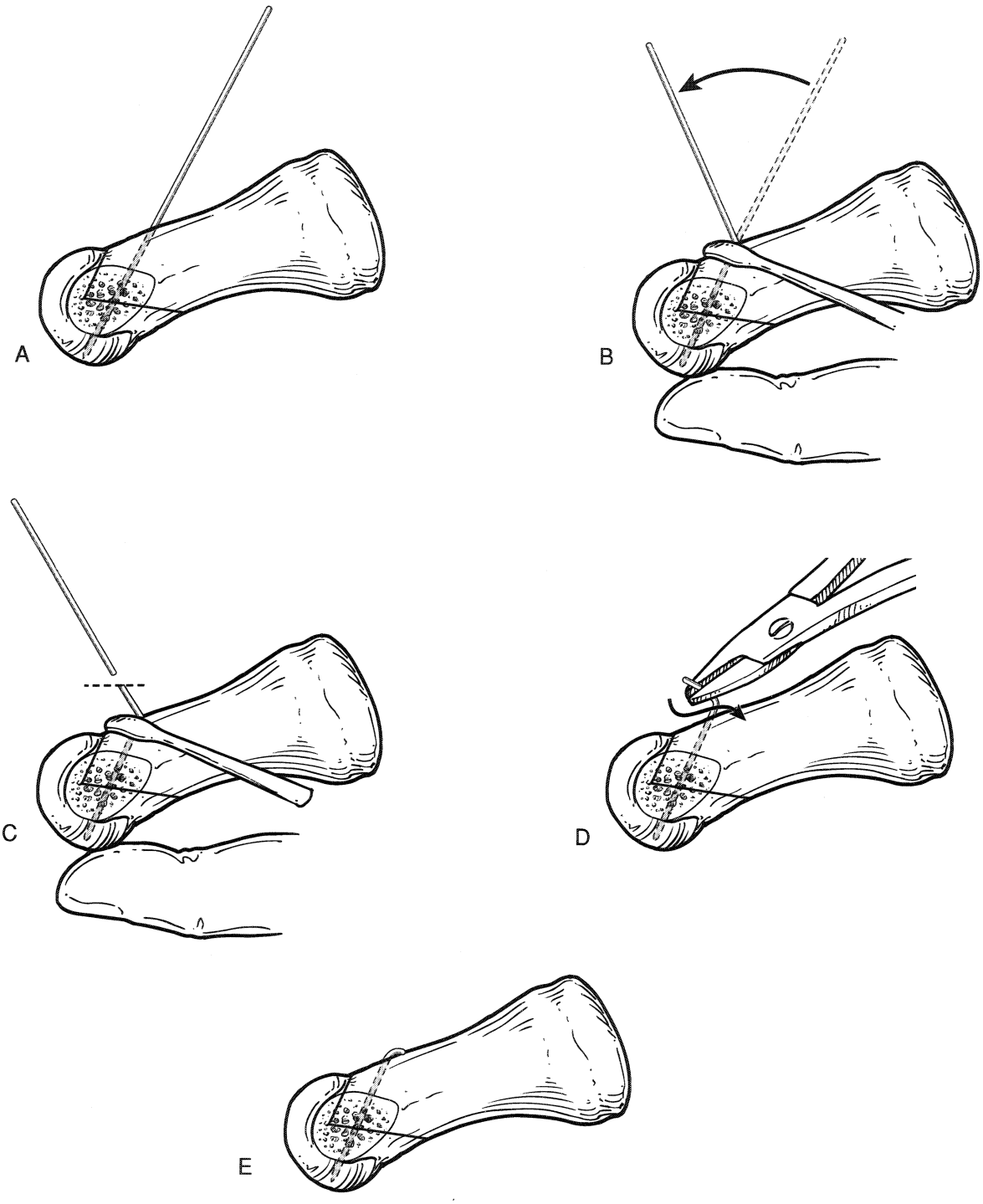
- visualize penetration of the pin through the plantar articular surface of metatarsal head, then withdraw the tip of the pin just inside the subchondral bone

- secure the dorsal cortex, distal to the pin with rasp or small periosteal elevator
- counter pressure with thumb up against the plantar aspect of the metatarsal head ***(fig. B)***

- bend the pin forward (approximately 30°) at the dorsal cortex over the stabilizing instrument ***(fig. B)***

- cut the pin approximately 1/4 inch from the bend with leading edge on the underside of the pin ***(fig. C)***

- rotate the pin 180° so that external portion of the pin "swages" against the dorsal cortex, capturing the bend and locking the pin in place ***(fig. D,E)***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I. NON-SCREW FIXATION TECHNIQUES

I.D. K-WIRE SPLINTAGE AND TENSION BAND TECHNIQUES (5TH METATARSAL AVULSION FRACTURE)

PURPOSE:

- demonstrate K-wire splintage and cerclage wire tension band fixation of an avulsion fracture
* single loop and figure "8", single twist technique

POINTS OF INSTRUCTION:

- cut the fracture of the styloid of the 5th metatarsal *(do not cut all the way through the bone)*
- reduce the fracture with a "double sharp" bone clamp

Splintage K-wire insertion

- insert (2) pins / 1.6 mm K-wires
- two pins are inserted in vertical orientation to each other (dorsal - plantar) ***(fig. A)***
  (may use parallel drill guide for accurate alignment of fixation pins)

- insert **1st pin** at the inferior aspect of the avulsion fragment *(essentially perpendicular to the fracture)* across the fracture and through the medial cortex
- insert the **2nd pin** at the superior aspect of the fragment with use of parallel drill guide
- pins should penetrate medial cortex

Tension Band Wire Loop ***(fig. D, E, F)***

- place a vertical drill hole (dorsal - plantar) approximately 1 cm distal to the fracture ***(fig. C)***
- vertical orientation, dorsal to plantar at lateral aspect of the metatarsal
- distance of the drill hole from the fracture should be the same as the distance of the penetration of the pins is proximal to the fracture - *equidistant spacing*

- **Single Loop**

- pass wire through distal drill hole from the dorsal aspect of the metatarsal and out the plantar ***(fig. D)***
- pass the proximal end of the wire around the two fixation pins and tie the knot on the plantar side of the bone

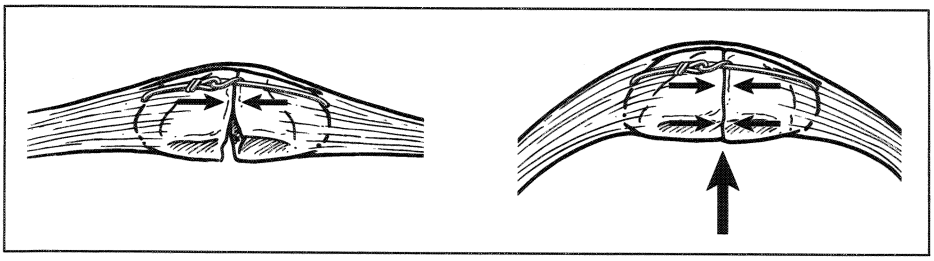
* *important that K-wires are in a vertical orientation so that wire loop will engage both wires*
** *if the K-wires are in a horizontal orientation, the wire loop will only engage the medial wire!!*

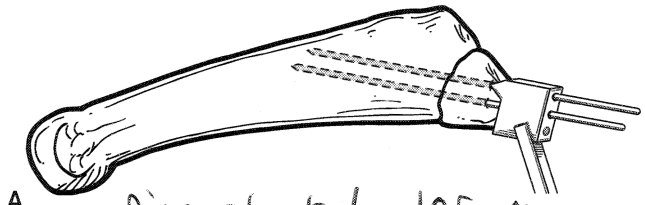
* **keep tension on the wire while twisting to prevent kinking** ***(fig. E)***
cut the twisted wire (approx. 1/4 inch) and press flat against the bone beneath the muscle belly

Bending and Seating of Splintage Pins ***(fig. F)***

- back up pins slightly to allow ease of insertion after bending the wires
- bend wires, cut and tap into the base of 5th metatarsal

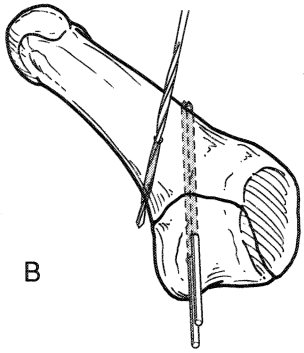
- **Figure "8" Wire Loop** can be used as an alternative technique ***(fig. G)***





A

pins stacked dorsal to plantar



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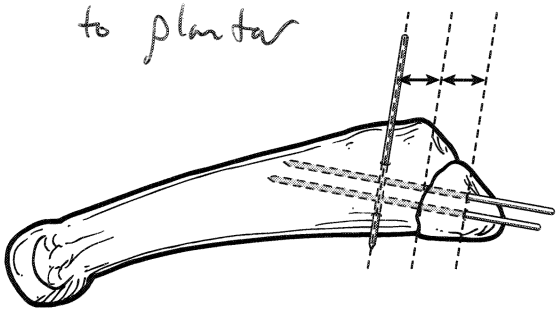

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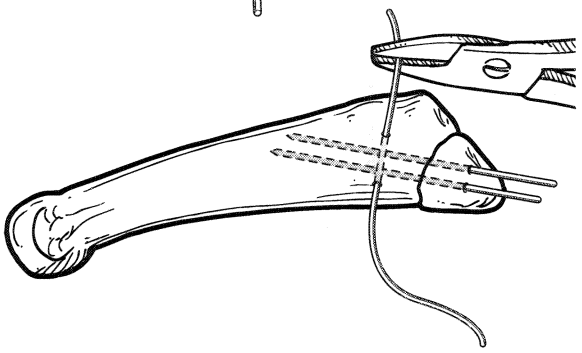

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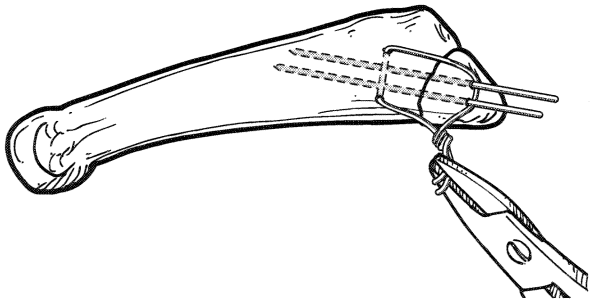

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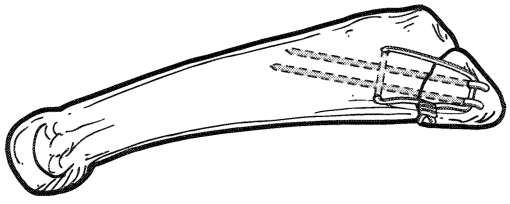

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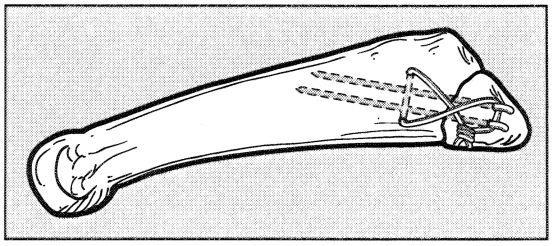


G

I. NON-SCREW FIXATION TECHNIQUES

I.E. IOL TECHNIQUES - HORIZONTAL (TB - 5TH METATARSAL / TRANSVERSE WEDGE OSTEOTOMY)

PURPOSE:

- demonstrate the technique of "Intra Osseous Loop" (IOL) wire fixation

POINTS OF INSTRUCTION:

- exostectomy

- Transverse osteotomy with lateral cortex intact ***(fig. A)***
  (observe hinge / axis principles)
  (pick the location of the transverse osteotomy proximal enough so that distal hole will be in cortical bone)

- (2) drill holes, lateral to medial ***(fig. B)***
  drill holes equidistant from the osteotomy
  drill holes horizontal and midway between dorsal and plantar cortices of the bone
  (1) distal to the osteotomy
  (1) proximal to the osteotomy.

- Cerclage wire
  28 ga. monofilament wire / double strand with helical twist
  (helical twist of 28 ga. monofilament wire is stronger than a single strand but still malleable, and tends to resist fracture at twist site)
  0.8 mm monofilament AO wire
  (AO wire is more malleable at larger diameters / made for cerclage techniques)

- pass the wire from lateral to medial to place knot / twist at the open side of the wedge osteotomy ***(fig. C, D, E)***

- pass wire through distal hole first, ***(fig. C)***
  this allows an easier pass of the wire in the distal segment and makes fracture of the hinge less likely when passing and manipulating the wire

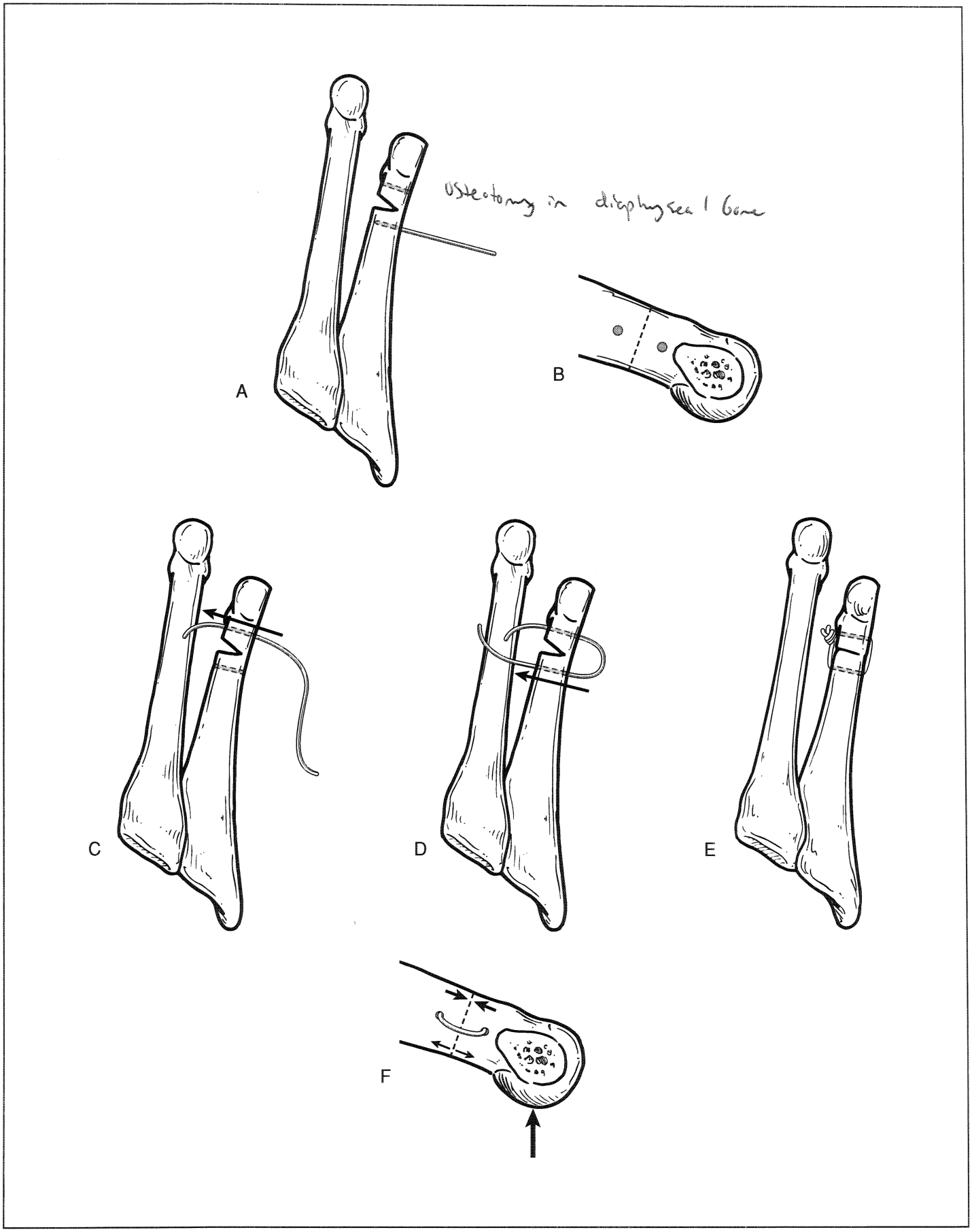
- pass proximal end of wire through proximal hole and then pull wire through stable, solid proximal bone without fracturing the lateral cortical hinge ***(fig. D)***

- press the intact wire flat over the intact lateral cortical hinge ***(fig. F)***

- manually reduce the osteotomy and twist the wire under tension at the medial aspect of the bone to hold closed the wedge osteotomy

- cut and press the end of the wire against the medial surface of the bone

* horizontal wire loop acts as a tension band device to resist gap at plantar aspect of the osteotomy and create compression at the dorsal aspect of the osteotomy with dorsiflexion pressure of weightbearing or any shift of the capital fragment


Osteotomy in diaphyseal bone
A
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C
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E
F

I. NON-SCREW FIXATION TECHNIQUES

I.F. IOL TECHNIQUES - VERTICAL (AKIN OSTEOTOMY / "HOOK AND LOOP" WIRE PASS TECHNIQUE)

PURPOSE:

- Akin osteotomy / transverse wedge osteotomy with intact lateral cortical hinge

- vertical IOL Loop, "hook and loop" pull through technique of passing the wire
- useful in areas where it may be difficult to pass a single strand of wire through two drill holes
  allows passage of separate wires through both drill holes,
  retrieval of individual wires from area of limited access
  connection of the ends of the wire outside of the surgical site
  "pull through" technique to pass distal wire up through the proximal hole and complete the "loop"

POINTS OF INSTRUCTION:

- Akin osteotomy
  transverse wedge osteotomy of the proximal phalanx *(observe hinge / axis principles)*
  lateral cortical hinge ***(fig. A, B)***

- anatomy or osteotomy may dictate the need for use of a vertical loop

"Hook and Loop" wire pass technique

- two drill holes, mid-line, dorsal through plantar cortex, equidistant from the osteotomy line ***(fig. B)***

- pass the "hook" wire from dorsal to plantar and pull through the distal hole ***(fig. C)***

- pass the "loop" wire from dorsal to plantar in the proximal hole and pull through ***(fig. C)***

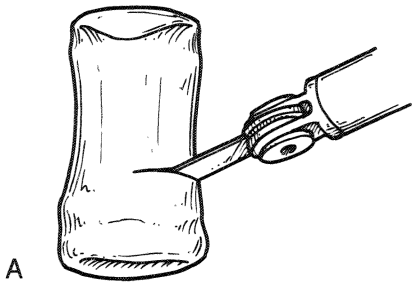
- connect *(insert the "hook" into "loop", and crimp "hook" segment with pliers to lock in place)* ***(fig. D)***

- guide the connection to the plantar aspect of the proximal drill hole with tension on the proximal wire

- pull up wire up through the proximal hole ***(fig. E)***
  (this technique pulls the wire up through the stable proximal fragment and lessens the possibility of fracture of the cortical hinge with manipulation and passage of the wire)

- twist, tie and cut ***(fig. F)***

- press cut end flat against the dorsal cortex ***(fig. G, H)***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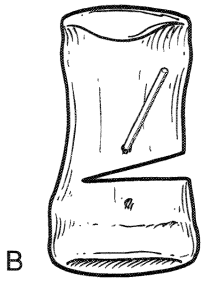
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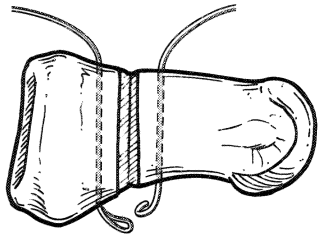
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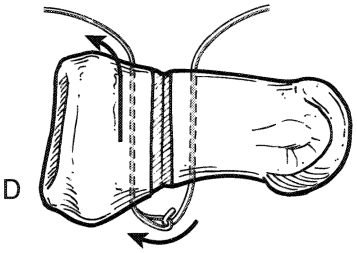
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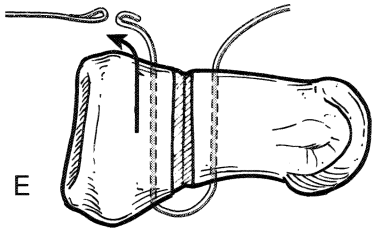
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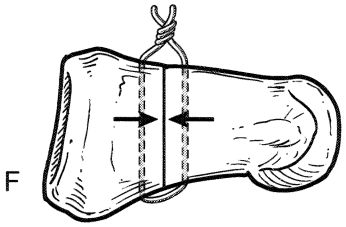
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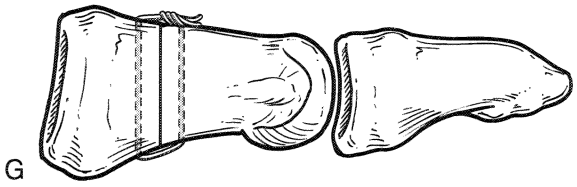
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H

I. NON-SCREW FIXATION TECHNIQUES

I.G. SALVAGE TECHNIQUES - (CERCLAGE)

PURPOSE:

- demonstrate salvage techniques to reinforce and augment fixation of long oblique osteotomies and fractures

- wire loop inserted perpendicular to the long axis of the bone ***(fig. B)***
  this orientation is the shortest distance between the cortices and the cerclage loop creates a secure fixation which prevents telescoping or shortening of the segment through a dynamic "tension band" effect AND prevents disruption or loosening of the primary compression screw

- wire loop may be inserted through an existing drill hole or around the two segments of the bone

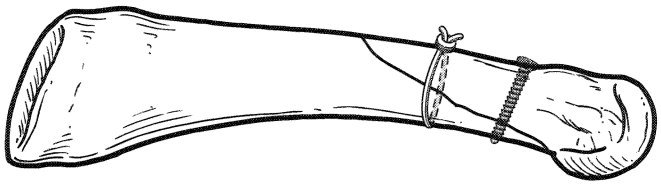
- 5th metatarsal oblique fracture / one screw and anchor wire ***(fig. A)***

- oblique base wedge / one screw and anchor wire ***(fig. B)***
  **cerclage loop is perpendicular to the long axis of the bone*

- oblique TB osteotomy / one screw and anchor wire ***(fig. C)***

- reinforcement of single screw fixation of an oblique Akin osteotomy ***(fig. D)***

- cerclage of small butterfly fragment within plate osteosynthesis ***(fig. E)***



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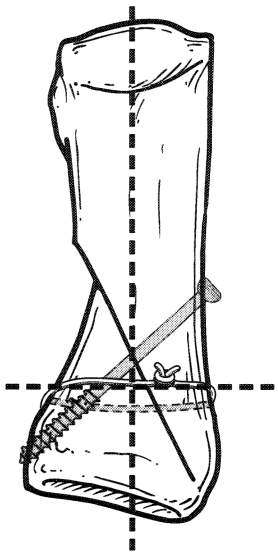

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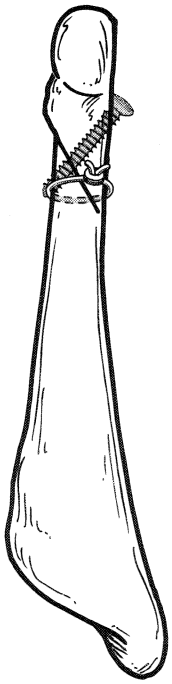

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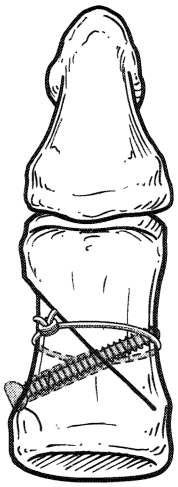

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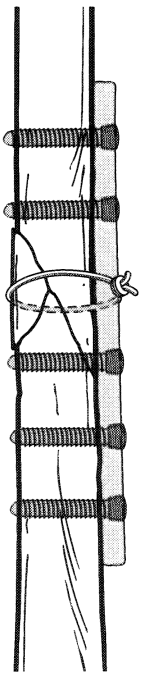


E

I. NON-SCREW FIXATION TECHNIQUES

I.H STAPLE FIXATION

- perpendicular to plane of arthrodesis, fracture or osteotomy ***(fig. A)***

- tendency of staple to compress "near" cortex and gap "far" cortex ***(fig. B)***

- 90° orientation of additional staple to prevent gap of "far" cortex ***(fig. C, D)***

- example of staple fixation of the calcaneocuboid joint ***(fig. E)***

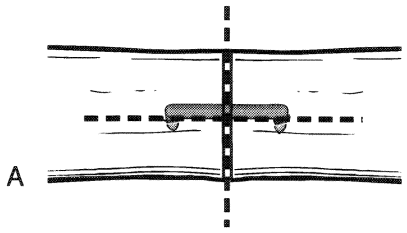
STAPLES

<u>can be used as supplemental point of fixation for primary screw fixation</u>

- example of use of a staple in an ankle fusion to add an additional point of fixation designed to prevent sagittal plane rocking at the ankle joint level ***(fig. F)***

- reinforcement of a single screw fixation of the talonavicular joint ***(fig. G)***

** Salvage technique*
- re-enforcement of split cortex at head of screw (arthrodesis technique) ***(fig. H)***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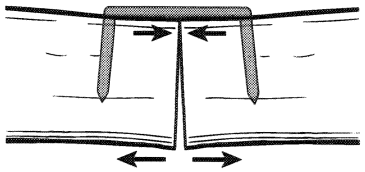
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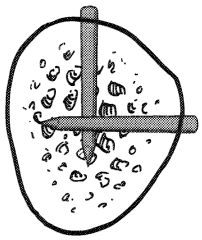
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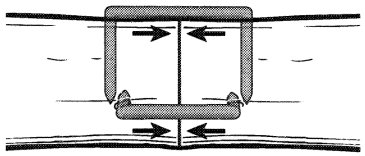
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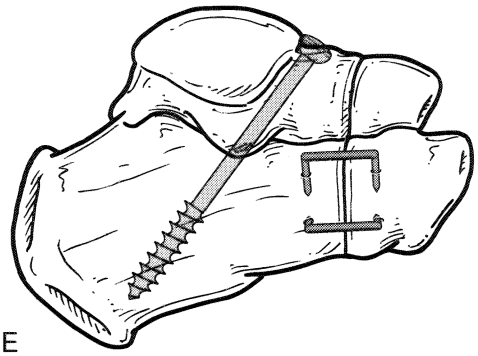
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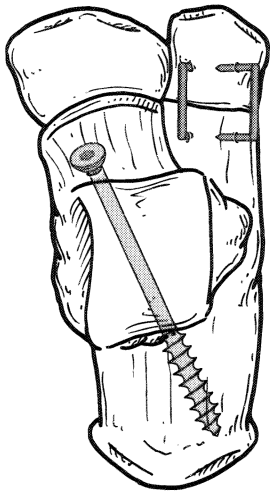

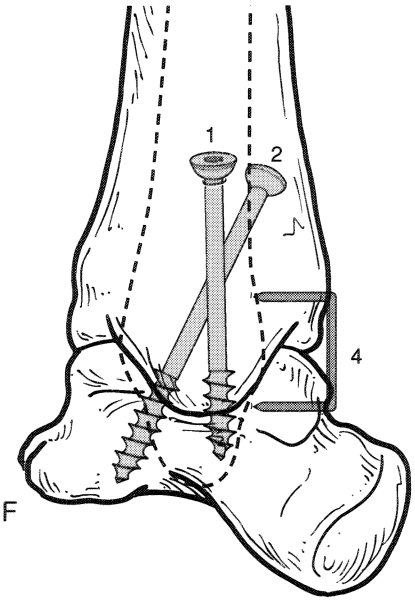

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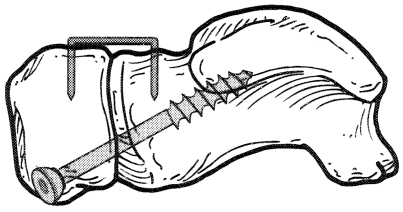
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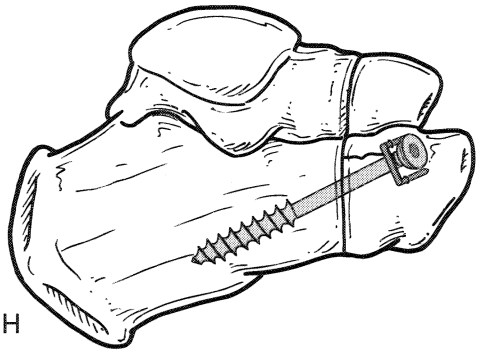

H

II. LAG SCREW TECHNIQUES

ANATOMY OF A SCREW

II.A.	"CANCELLOUS" SCREW - LAG TECHNIQUE	- 4.0 MM "PARTIALLY THREADED" CANCELLOUS SCREW
II.B.1.	"NO COMPRESSION" CORTICAL SCREW TECHNIQUE	- 3.5 MM CORTICAL SCREW
II.B.2.	**WITH CONVERSION TO A "LAG" SCREW FUNCTION*	
II.C.	"STANDARD" CORTICAL SCREW - LAG TECHNIQUE	- 3.5 MM CORTICAL SCREW
II.D.	"SMALL BONE" CORTICAL SCREW - LAG TECHNIQUE	- 2.7 MM CORTICAL SCREW
II.E.	"COMPROMISE" COMPRESSION TECHNIQUE	- 3.5 MM CORTICAL SCREW

II. LAG SCREW TECHNIQUES

ANATOMY OF A SCREW

Components of a screw include:

- Head
- Land
- Shank
- Run Out
- Core
- Thread
- Purchase
- Pitch
- Tip

Head - functions as proximal securing point of the device to the bone ***(fig. A)***
site for attachment of the "driver" to the device

Land - provides contoured, greater surface area of contact of the head of the screw to the ***(fig. B)***
proximal bone cortex... to reduce stress risers

Shank - region void of a thread pattern in a partially threaded screw ***(fig. D)***

Run Out - where threads meet the shaft and is the "weakest" part of the screw / ***(fig. D)***
recommend shielding the "Run Out" by placing it as far from the fracture as possible

Core Diameter - portion of the shaft within the thread pattern ***(fig. E)***
the larger the "core diameter", the greater resistance the screw has to bending loads

Thread Diameter - width of the screw threads which connotes the "size" of the screw ***(fig. E)***

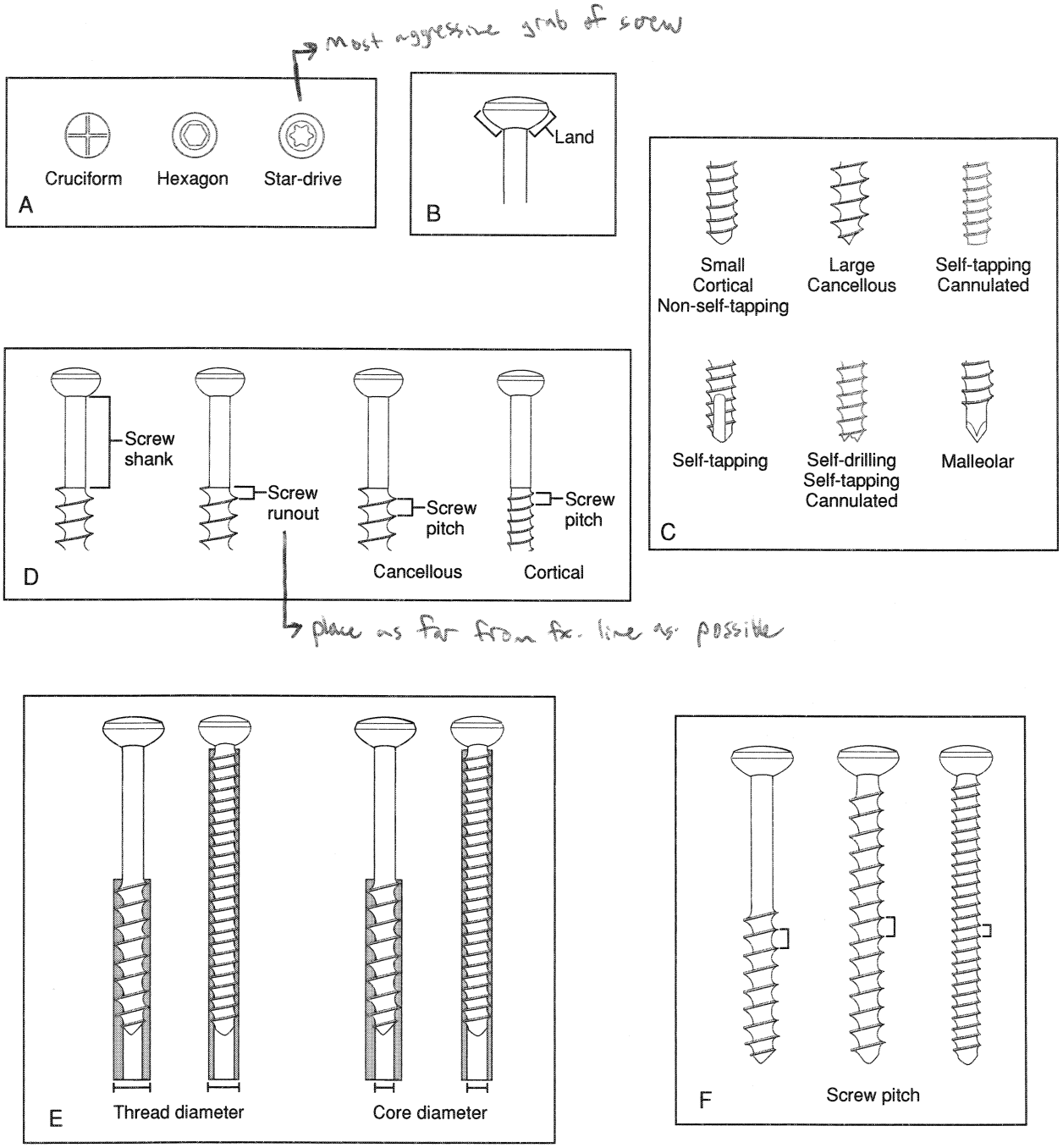
Purchase - thread diameter minus the core diameter equals the amount of thread
purchase in the bone ***(fig. E)***

Pitch - distance between adjacent threads, angle or slope ***(fig. F)***
two basic patterns include cortical and cancellous thread patterns

Cortical thread patterns are closer together with greater a core diameter to thread ratio
creating a stronger screw with more points of thread contact in harder bone

Cancellous threads have a larger thread to core relationship and are farther apart,
more suited for purchase in softer cancellous bone

Tips - rounded / solid screws, non self-drilling, non self-tapping ***(fig. C)***
pointed / large, 6.5 mm cancellous screws, non-self tapping
fluted / solid, self-tapping, cortical screws
serrated / cannulated, self-drilling, self-tapping
non-serrated / cannulated, self-tapping
trochar / 4.5 mm "malleolar" screw


most aggressive grab of screw
Cruciform
Hexagon
Star-drive
A
Land
B
Small Cortical Non-self-tapping
Large Cancellous
Self-tapping Cannulated
Self-tapping
Self-drilling Self-tapping Cannulated
Malleolar
C
Screw shank
Screw runout
Screw pitch
Screw pitch
Cancellous
Cortical
D
place as far from fx. line as possible
Thread diameter
Core diameter
E
Screw pitch
F

II. LAG SCREW TECHNIQUES

II.A. "CANCELLOUS" SCREW - LAG TECHNIQUE

4.0 mm - "partially threaded" Cancellous Screw

PURPOSE:

- to demonstrate the interfragmental compression created by proper insertion of a cancellous screw

POINTS OF INSTRUCTION:

- Overdrill / gliding hole is not necessary in proximal cortex

- All threads must cross the fracture or osteotomy to create "lag" effect

Insertion Sequence - 4.0 mm "partially threaded" Cancellous Screw Small Fragment Set (SFS)

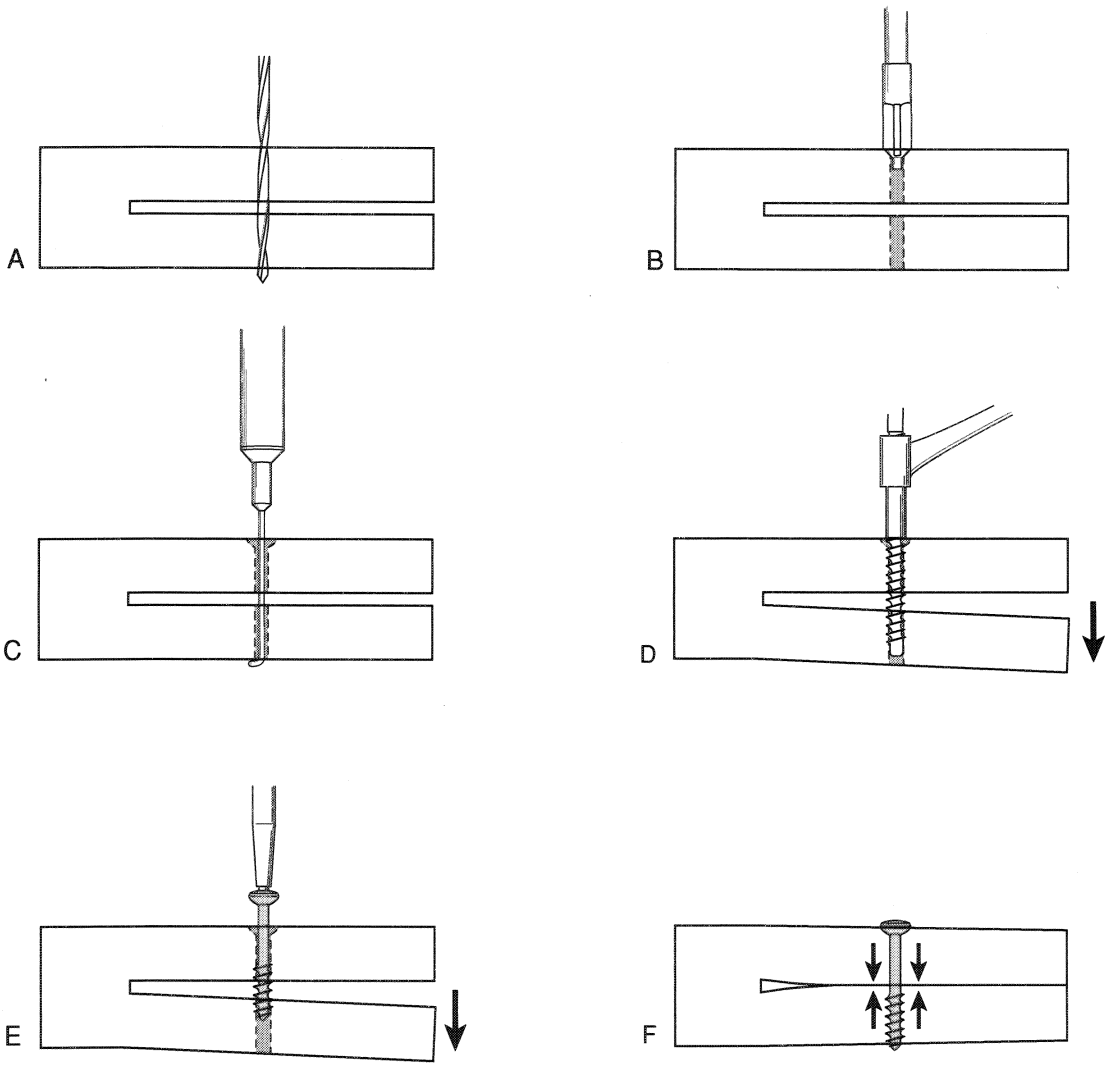
- thread hole - 2.5 mm drill ***(fig. A)***
(insert the drill through the proximal and distal cortices / "near" and "far" cortices)

- countersink - 2.5 mm tip (SFS countersink) ***(fig. B)***
(keep in line with thread hole or true path of the screw)
(increases contact surface and reduces the potential for stress risers)

- depth gauge *(measures the length of screw needed)* ***(fig. C)***

- tap - 4.0 mm cancellous tap (1.75 mm pitch) ***(fig. D)***
*Use of "drill sleeve" protects soft tissues and prevents toggling of the tap
(rotate 3-4 turns forward, then reverse 1-2 turns to clear flutes)
(note gapping at the fracture as the tip of the tap contacts the distal cortex)

- screw - 4.0 mm "partially threaded" cancellous screw ***(fig. E, F)***
(note gap of the fracture when tip of screw initially contacts the distal cortex, then closure of the fracture gap when the head of screw contacts the near cortex and the threads clear the fracture to fully engage the distal side)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II. LAG SCREW TECHNIQUES

II.B.1. "NO COMPRESSION" CORTICAL SCREW INSERTION TECHNIQUE

with conversion to a "Lag" screw function

3.5 mm Cortical Screw

PURPOSE:

- to demonstrate the inability to create interfragmental compression without the use of a "gliding hole" when inserting a fully threaded cortical screw

POINTS OF INSTRUCTION:

- Interfragmental compression can not be created if near cortex is not "over-drilled"

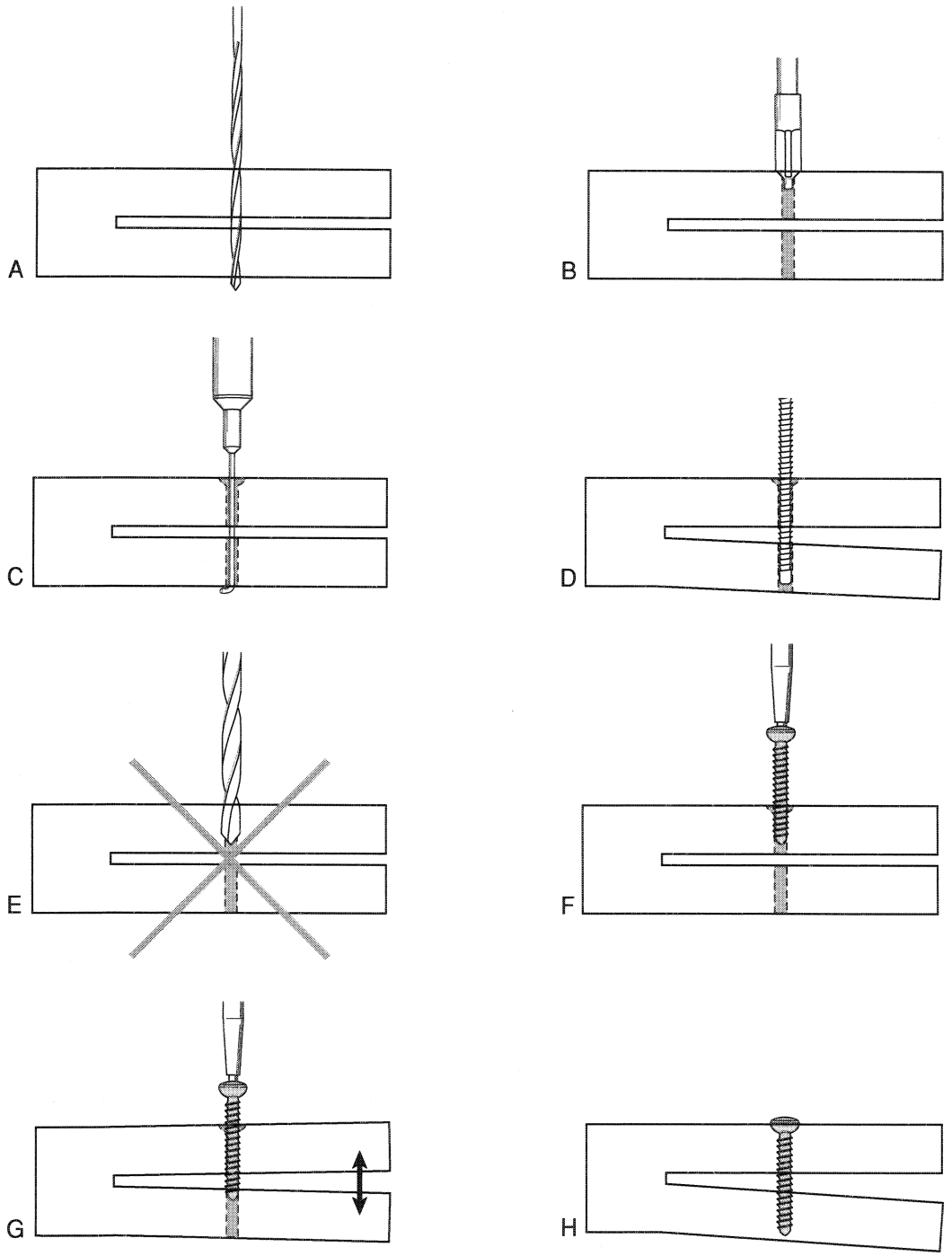
Insertion Sequence - 3.5 mm cortical screw

- **thread hole - 2.5 mm drill** ***(fig. A)***
- **countersink** ***(fig. B)***
- **depth gauge** ***(fig. C)***
- **tap - 3.5 mm cortical tap** *(1.25 mm pitch)* ***(fig. D)***

⊘ **NO over-drill** ***(fig. E)***

- **Insert 3.5 mm cortical screw** → "⊘" compression ***(fig. F, G, H)***

Closure of the fracture gap is not possible because the two fragments are fixed on the threads of the screw. The proximal fragment cannot slide or be pushed to the far fragment.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II. LAG SCREW TECHNIQUES

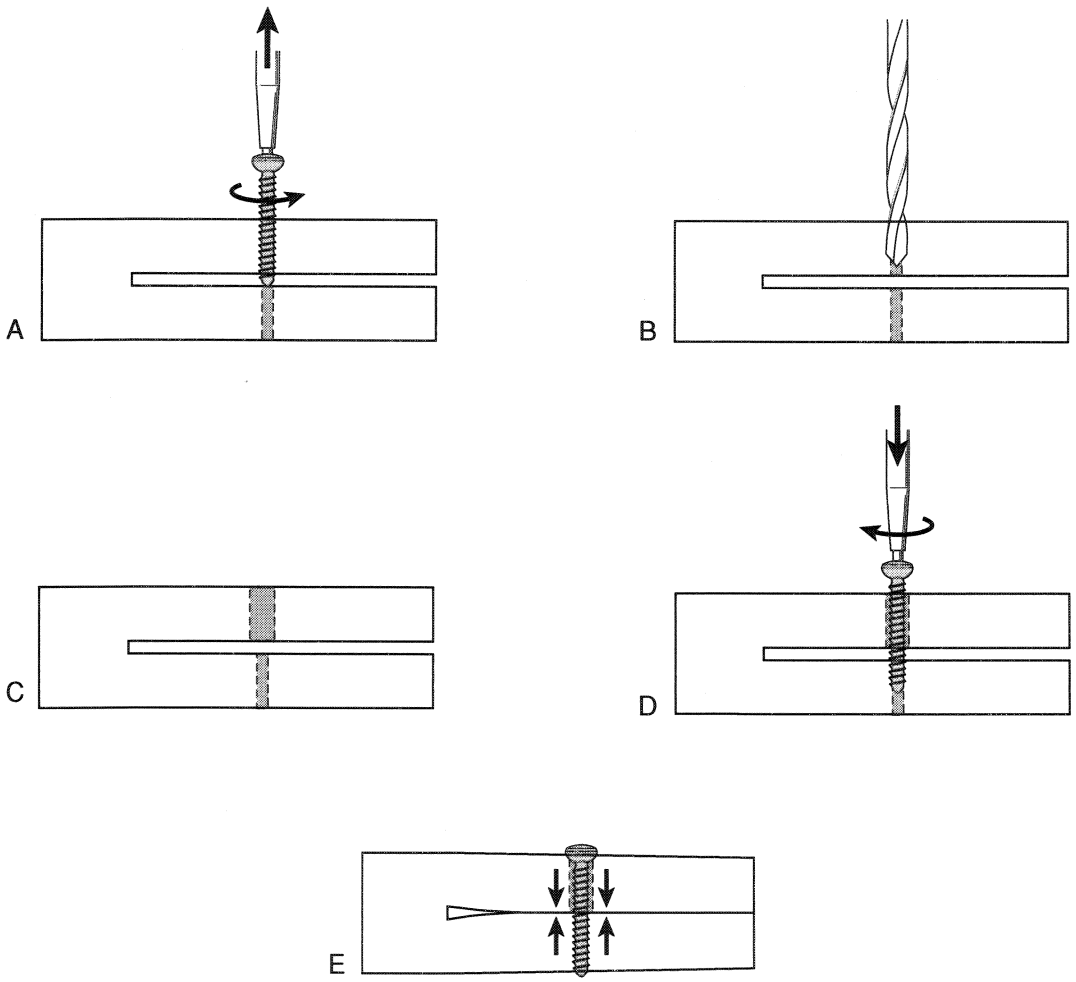
II.B.2. CONVERSION OF A "NO COMPRESSION" CORTICAL SCREW INSERTION *to a "Lag Screw" Compression Technique*

- REMOVE - Small Cortical Screw (3.5 mm) *(fig. A)*
- "OVERDRILL" - 3.5 mm drill... Near Cortex ONLY! *(fig. B, C)*
- RE-INSERT - Small Cortical Screw (3.5 mm) *(fig. D, E)*

Observe the effect of "over-drilling"

- insert the screw through the near cortex to the far cortex without rotation of the screw
- advance the screw by rotation as the threads engage the far cortex
- as the head of the screw contacts the near cortex, the screw spins freely in the "glide hole"
- the threads of the screw engage the far cortex and pull the far fragment toward the near fragment creating compression between the two fragments as the screw advances...

- "Lag" effect is created with a fully threaded cortical screw by overdrilling or creating a "glide hole" in the proximal fragment or near cortex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II. LAG SCREW TECHNIQUES

II.C. "STANDARD" CORTICAL SCREW - LAG TECHNIQUE

*Technique used for lag insertion of 4.5 mm and **3.5 mm** Cortical Screws in large tubular bones*

3.5 mm - Cortical Screw

POINTS OF INSTRUCTION:

- technique begins with the "overdrill" followed by execution of the thread hole in the far cortex with the use of a "T" sleeve for guide control

Insertion Sequence - 3.5 mm cortical screw

- over-drill - **3.5 mm drill** ***(fig. A)***
- *over-drilling here with a 3.5 mm drill bit must be done very cautiously so as to drill only the near cortex*

!!! **the point of the drill bit must NOT cross the fracture line or osteotomy**

- "T" sleeve 3.5 mm outside diameter / 2.5 mm inside ***(fig. B)***
- *insert the "T" sleeve through the "over drill" in the near cortex until the guide contacts the internal surface of the far cortex*

- *inserted to control point of penetration of the 2.5 mm drill through distal cortex*
- *prevents sliding of the 2.5 drill bit along the inside of the far cortex*

* *serrated tip of the drill sleeve engages the distal cortex and prevents movement or migration of the thread drill as it attempts to penetrate the distal cortex*

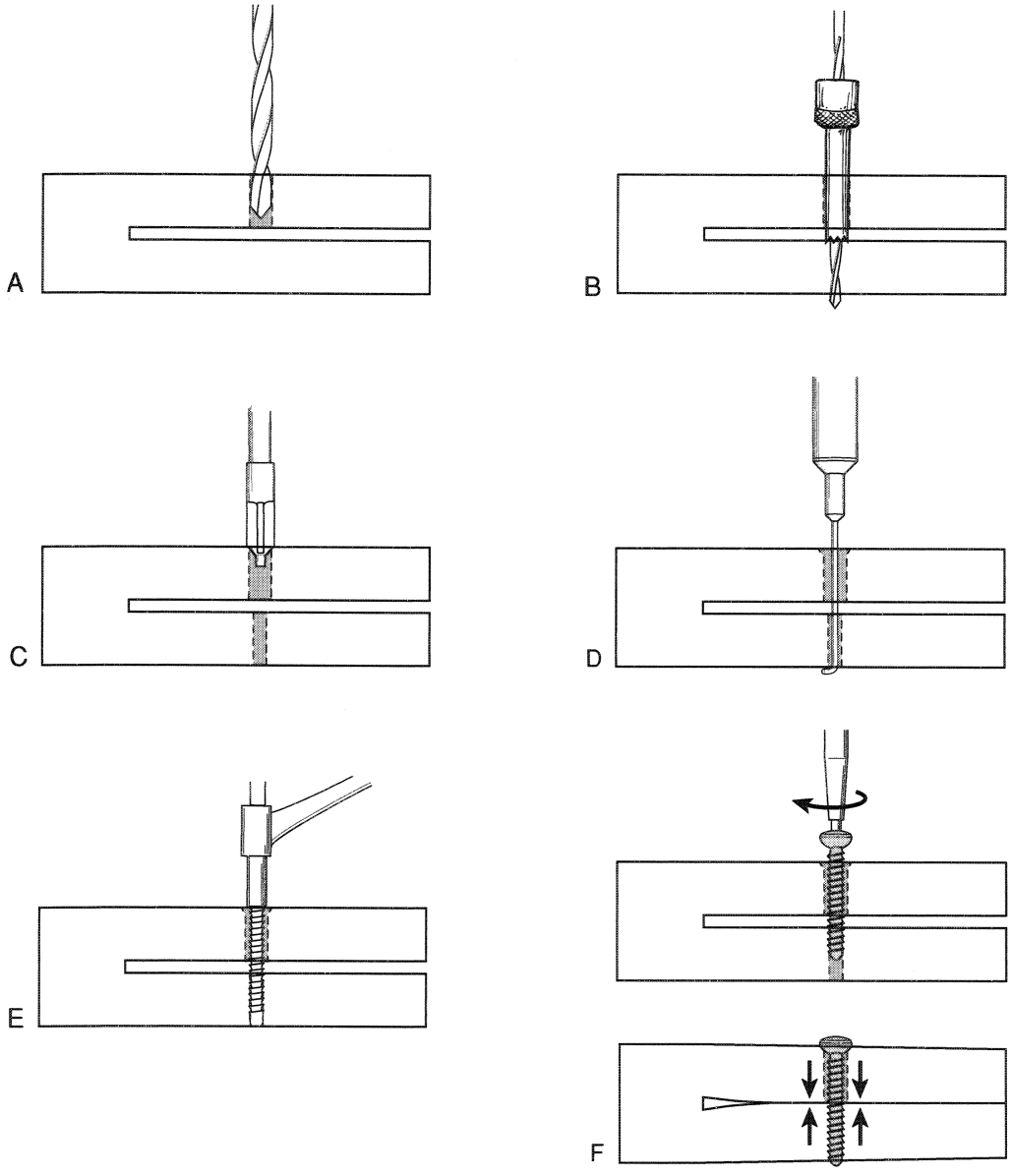
- thread hole - **2.5 mm drill** ***(fig. B)***
- *inserted through the "T" sleeve*

- countersink - *increases contact surface and reduces chance of stress riser* ***(fig. C)***
** *accurate, concentric countersinking occurs when the insertion technique is perpendicular to the near cortex, allowing the countersink to be "self-centering"*

- depth gauge *(measures the length of screw needed)* ***(fig. D)***

- tap - **3.5 mm cortical tap** *(1.25 mm pitch)* ***(fig. E)***
(forward / reverse technique to clear flutes)

- screw - **3.5 mm cortical screw** ***(fig. F)***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II. LAG SCREW TECHNIQUES

II.D. "SMALL BONE" CORTICAL SCREW - LAG TECHNIQUE

*Technique used for Small Cortical Screws in small bones (1.5, 2.0, 2.4, **2.7**, 3.5 mm)*

2.7 mm Cortical Screw

POINTS OF INSTRUCTION:

- this technique utilizes the "thread hole" as the initial step in the sequence and the "overdrill" is created in near cortex just before insertion of the screw to create the "lag" effect

Insertion Sequence - 2.7 mm cortical screw

- thread hole - **2.0 mm drill** ***(fig. A)***
(insert drill bit through the proximal and distal / "near" and "far" cortices)

- countersink *(increases contact surface and reduces chance of stress riser)* ***(fig. B)***
(countersinking here will almost create an effective "glide hole")

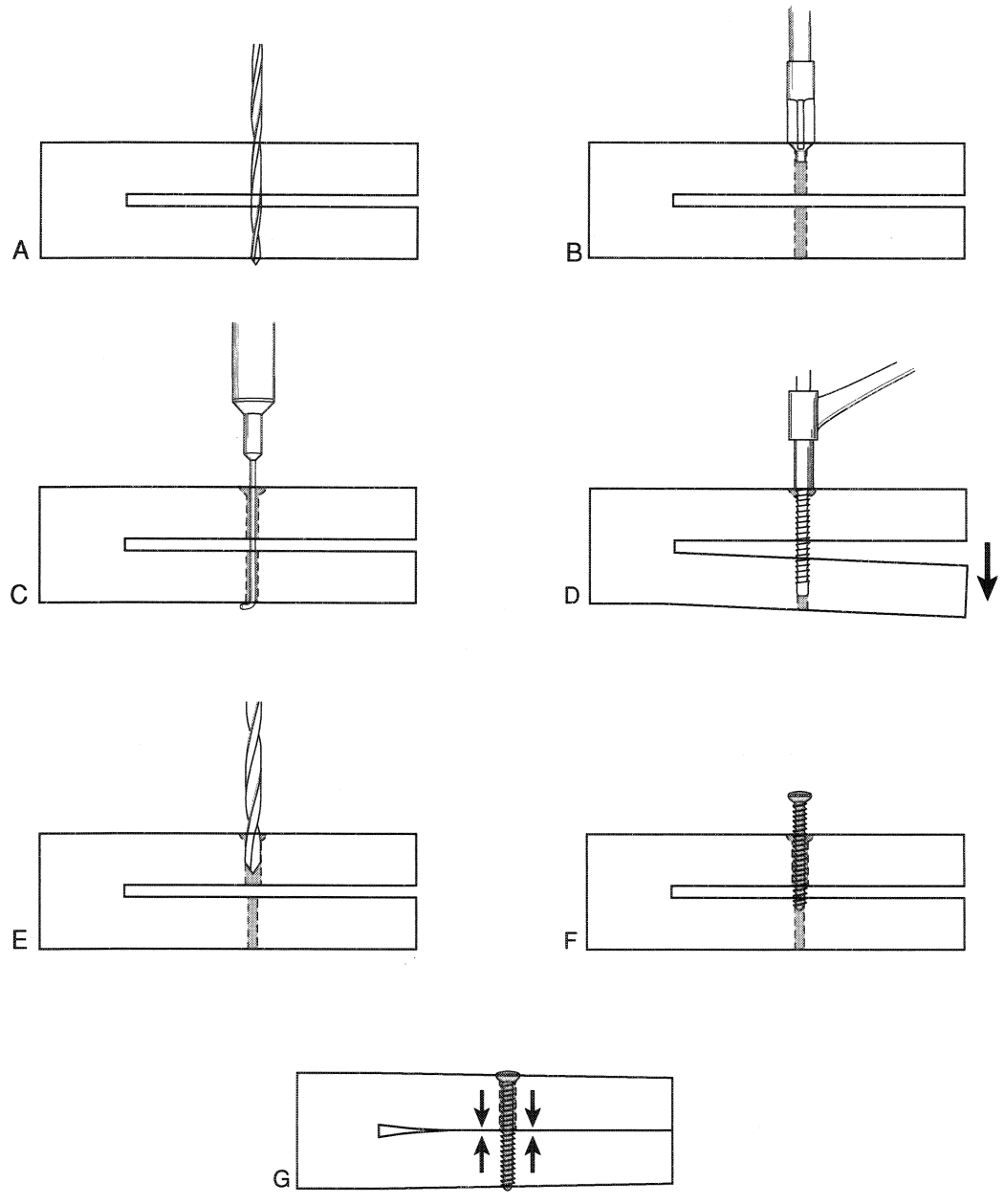
- depth gauge *(measures the length of screw needed)* ***(fig. C)***

- tap - **2.7 mm cortical tap** *(1.25 mm pitch)* ***(fig. D)***

- over-drill - **2.7 mm drill** ***(fig. E)***
(over-drilling here with a 2.7 mm drill bit must be done very carefully so as to drill only the near cortex)

!!! the point of the drill bit must NOT cross the fracture line or osteotomy

- screw - **2.7 mm cortical screw** *"two-finger tightness"* ***(fig. F, G)***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II. LAG SCREW TECHNIQUES

II.E. "COMPROMISE" COMPRESSION TECHNIQUE

3.5 mm Cortical Screw

POINTS OF INSTRUCTION:

* close and reduce the fracture gap with a bone clamp

- interfragmental compression is created by application of the bone clamp

- insertion of a 3.5 mm cortical screw without a "gliding hole" captures the interfragmental compression created by the bone clamp

- purchase of the screw threads in both cortices creates a more stable fixation by increased resistance to toggling and loosening of the screw with any micromotion

Insertion Sequence - 3.5 mm cortical screw

- use the bone clamp to reduce fragments and create interfragmental compression ***(fig. A)***

- thread hole - **2.5 mm drill** ***(fig. B)***

- countersink ***(fig. C)***

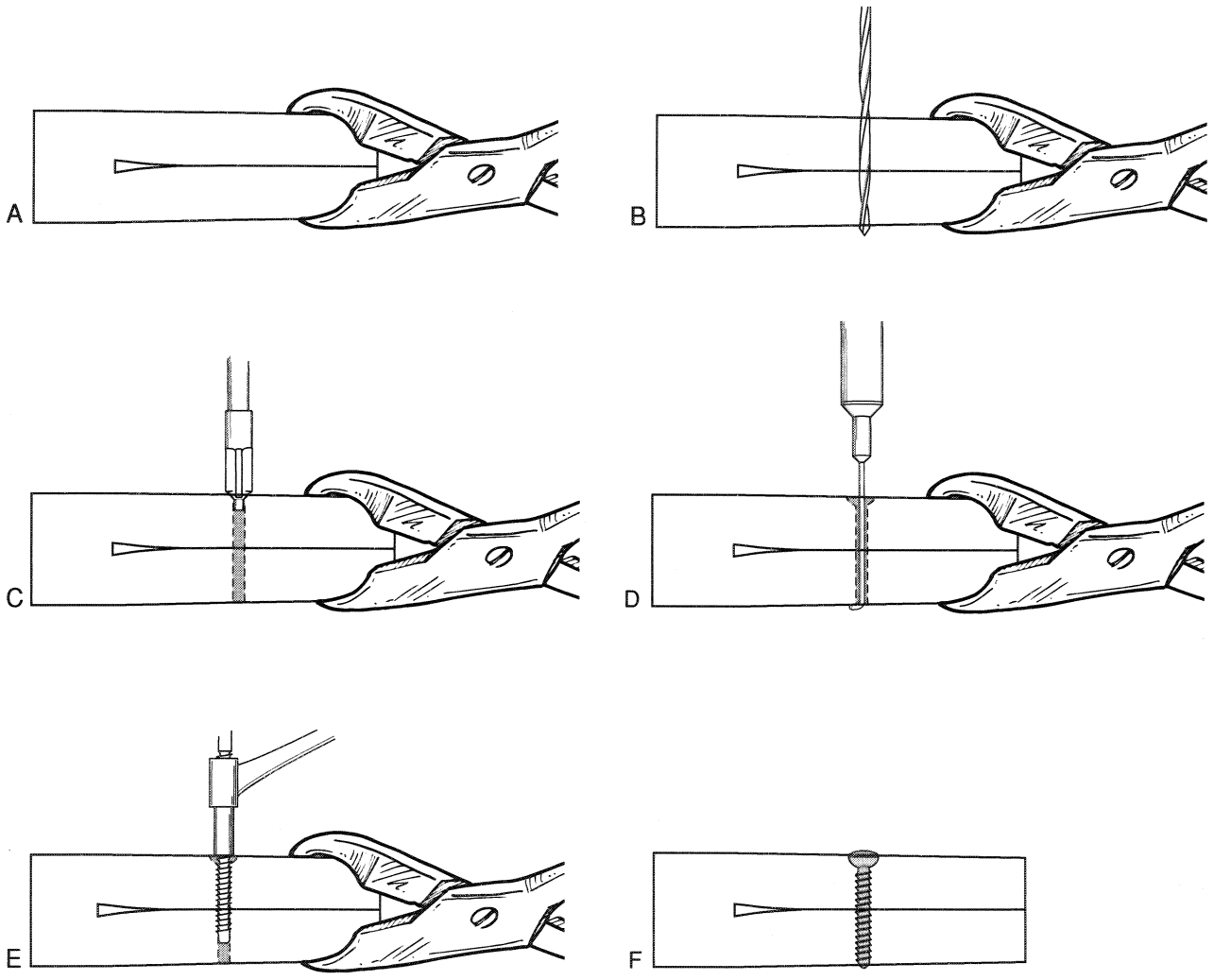
- depth gauge ***(fig. D)***

- tap - **3.5 mm cortical tap** ***(fig. E)***

- NO "overdrill"

- insert screw - **3.5 mm cortical screw** ***(fig. F)***

***screw "captures" compression created by the bone clamp**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III. OBLIQUE SCREW ORIENTATIONS

III.A. AKIN OSTEOTOMY

Technique: *- short oblique / single screw / **"half-way" between perpendiculars***
- 2.7 mm cortical screw / "small bone" cortical screw "lag" technique

III.B. LONG OBLIQUE FRACTURE

Technique: *- **"anchor" and "compression" screws***
- 3 screws / 2.7 mm cortical / "small bone" cortical screw "lag" technique

III.C. OBLIQUE BASE WEDGE OSTEOTOMY / HALLUX VALGUS OSTEOTOMY

Technique: *- "podiatric" modification / **2 screw technique***
- "anchor" and "compression" screw
- 2 screws / 4.0 mm cancellous

III.D.1. DFWO / "T"- SLEEVE TECHNIQUE

Technique: *- "Standard" cortical "Lag" technique*
- 1 screw / 3.5 mm cortical

III.D.2. NUANCES OF OBLIQUE SCREW INSERTION

III.D.3. DFWO / "T"- SLEEVE TECHNIQUE / "MODIFIED" TECHNIQUE

Technique: *- "Standard" cortical "Lag" technique*
- 1 screw / 3.5 mm cortical

III. OBLIQUE SCREW ORIENTATIONS

III.A. AKIN OSTEOTOMY

Technique: *- short oblique / single screw / **"half-way" between perpendiculars***
- 2.7 mm cortical screw / "small bone" cortical screw "lag" technique

PURPOSE:

- to demonstrate single screw fixation of a short oblique osteotomy utilizing "half-way between perpendiculars" orientation of the compression screw

POINTS OF INSTRUCTION:

Osteotomy Technique

- axis guide (proximal lateral aspect of base) ***(fig. A)***
- cut oblique osteotomy in proximal phalanx ***(fig. B)***
  (exit medial cortex distal to the midpoint of the bone)
- reduce osteotomy with bone clamp

- screw orientation "half-way between the perpendiculars" ***(fig. C)***

Insertion Sequence - 2.7 mm cortical screw / "Small Bone" Cortical Screw "Lag" Technique

- pre-drill (Suggested Technique) 1.6 mm K-wire or 0.062 K-wire ***(fig. C)***
(allows for fine control of the drill hole through the near and far cortices)

(half-way between perpendicular to the long axis of the bone and the perpendicular to the osteotomy)

- thread hole 2.0 mm drill ***(fig. D)***

- countersink ***(fig. E)*** *(make sure that the alignment of the countersink matches the path of the screw so that the screw head will clear the proximal edge of the countersink and not shift the screw distally as the screw head engages the countersink)*

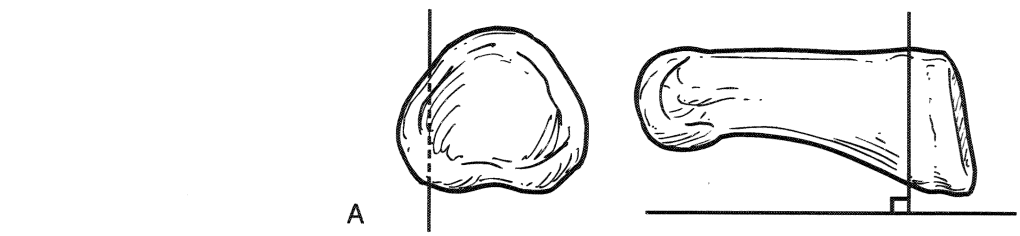
- depth gauge *(measure length at distal edge of exit hole)* ***(fig. F)***

- tap 2.7 mm cortical tap ***(fig. G)***

*** over-drill** 2.7 mm drill ***(fig. H)***
(through medial "proximal" cortex only)

- insert screw 2.7 mm cortical screw ***(fig. I)***

** ***single screw fixation can be reinforced and protected by the addition of a transversely applied "cerclage" loop (refer to illustration on page 19)***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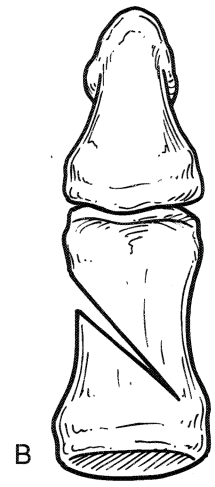
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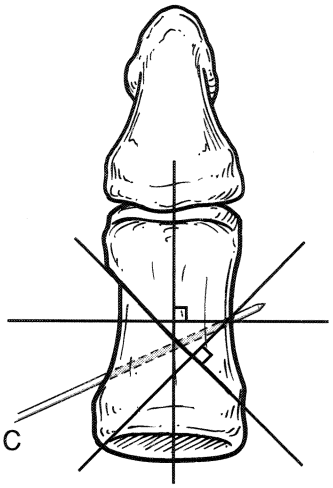
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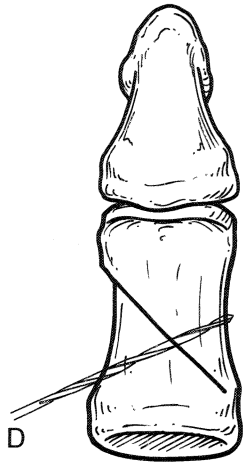
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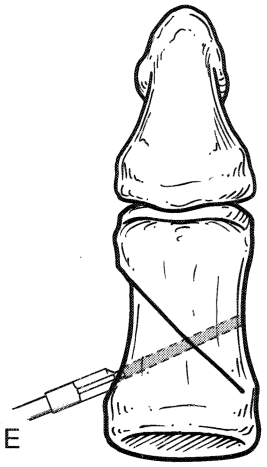
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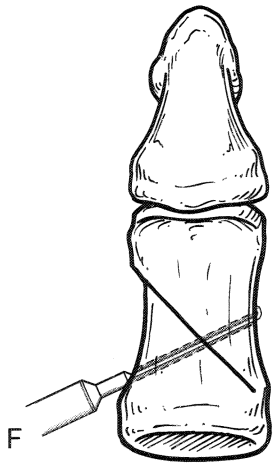
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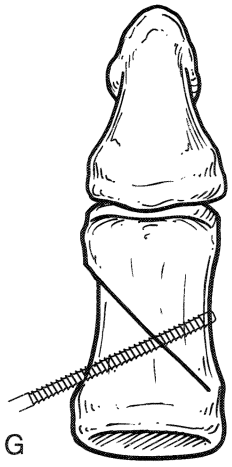
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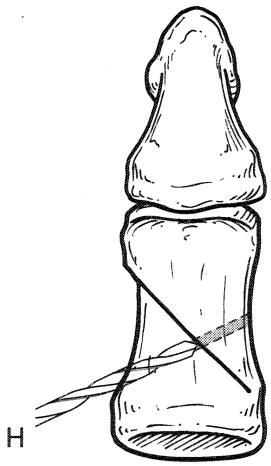
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I

III. OBLIQUE SCREW ORIENTATIONS

III.B. LONG OBLIQUE FRACTURE

prevents telescoping

Technique: *- **"anchor" and "compression" screws***
- 3 screws / 2.7 mm cortical / "small bone" cortical screw "lag" technique

PURPOSE:

- demonstrate principles and technique of screw fixation of a long oblique fracture including the "anchor" screw and individual compression screws

POINTS OF INSTRUCTION:

- cut a long oblique fracture in a lesser metatarsal (horizontal, lateral to medial)
* don't cut all the way through
- reduce with "lobster claw" bone clamp

- 1st screw, "Anchor" screw *(fig. A)*

perpendicular to long axis of bone *(dorsal to plantar in the middle of the fracture)*
anchor screw prevents telescoping of oblique fractures...

- shortest distance between dorsal/plantar cortices...
- this distance would tend to increase if fracture telescopes...
- telescoping of the fracture would require the head of the screw to pull through the dorsal cortex or the threads to pull out of the plantar cortex

- "Compression" screws *(fig. B, C)*

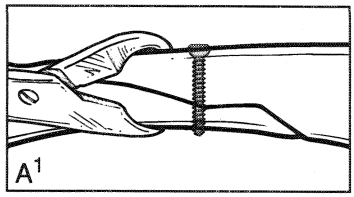
additional screws, one proximal and one distal,
* perpendicular to plane of fracture in the sagittal and transverse planes ***(fig. C, D)***
(particularly important concept in spiral fractures)

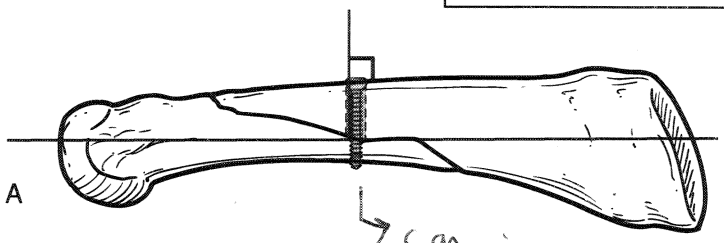
Insertion Sequence - 2.7 mm cortical screw / "Small Bone" Cortical Screw "Lag" Technique

- pre-drill	1.6 mm or 0.062 K-wire
- thread hole	2.0 mm drill
- countersink	*(make sure alignment of countersink matches path of screw to clear the proximal edge of the countersink for head of the screw)*
- depth gauge	
- tap	2.7 mm cortical tap
✱ over-drill /	2.7 mm drill *(near cortex only)*
- insert	2.7 mm cortical screw

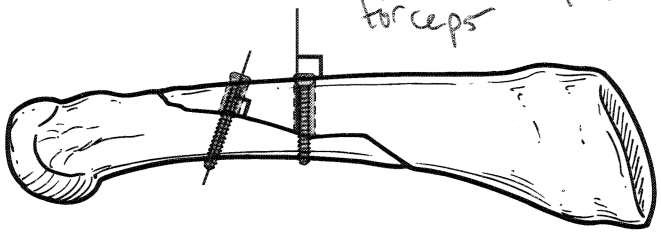
- Repeat technique for "compression" screws

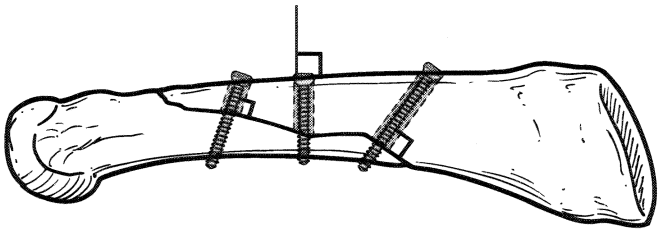
** **"Compromise" technique may be used for initial "anchor" screw *(fig. A-1)***
- purchase of the screw threads in both cortices creates a more stable fixation by increased resistance to toggling and loosening of the screw with any micromotion

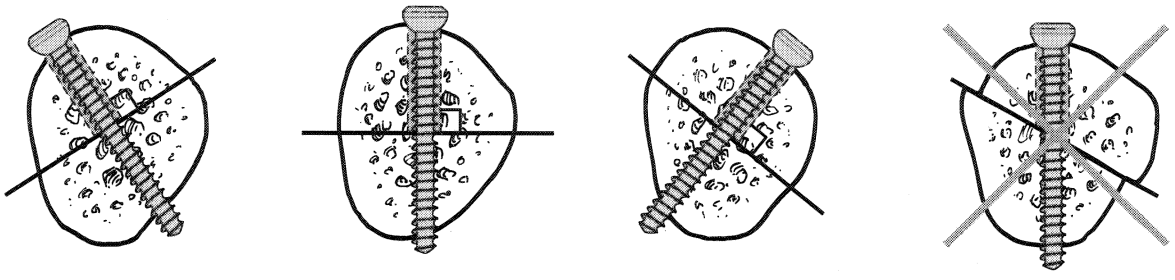




↳ can insert a compromise lag screw technique & bone reducing forceps







III. OBLIQUE SCREW ORIENTATIONS

III.C. OBLIQUE BASE WEDGE OSTEOTOMY / HALLUX VALGUS OSTEOTOMY

Technique: - *"podiatric" modification / 2 screw technique*
- ***"anchor" and "compression" screw***
- *2 screws / 4.0 mm cancellous*

PURPOSE:

- use of the axis guide for orientation and manipulation of the oblique base wedge osteotomy ***(fig. A)***
- to incorporate the principles and techniques of short and long oblique fracture fixation into the oblique base wedge osteotomy, "anchor" and "compression" screws

POINTS OF INSTRUCTION:

Osteotomy Technique

- axis guide placement
- as far proximal as possible, *(don't cut into MC joint with osteotomy)*
- orient axis guide in the frontal plane to control dorsiflexion or plantarflexion with closure of the osteotomy
- cut proximal arm of the osteotomy 1st *(determines orientation of screws to final osteotomy)*
- cut distal arm of the osteotomy 2nd
- remove the wedge and axis pin
- reduce osteotomy, secure with bone clamp ***(fig. B)***

✱ **2 screw technique - (2) x 4.0 mm "partially threaded" cancellous screws** ***(fig. C)***

- **1st screw**, "anchor" screw... perpendicular to long axis of bone,,, proximal and superior... ***(fig. D)***

- **2nd screw**, "compression" screw... distal and inferior... perpendicular to osteotomy... ***(fig. E)***
(threads engage dense cortex at plantar lateral aspect of the base of the metatarsal)

✱ try to keep screw heads separated by 1 cm ***(fig. C)***

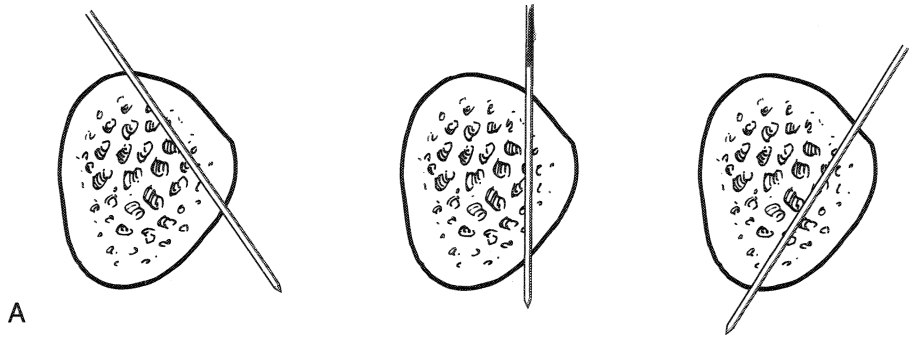
Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- pre-drill	1.6 mm K-wire
- thread hole	2.5 mm drill
- countersink	*(keep in line with thread hole)*
- depth gauge	
- tap	4.0 mm cancellous tap *(1.75 mm pitch)*
- screw insertion	4.0 mm "partially threaded" cancellous screw

Alternative screw techniques (2 x 2.7), (2 x 3.5), (2.7 + 3.5), etc., ***(fig. F)***

* **Salvage**, reinforcement, augmentation with cerclage wire loop perpendicular to long axis ***(page 19, fig. B)***

dorsomedial lunge - PF
⊥ to ground - no rotation
dorsolateral to plantar medial



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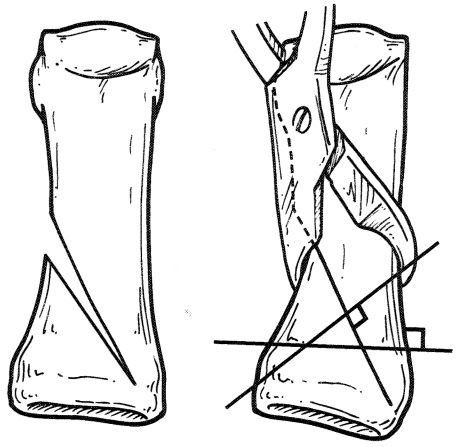

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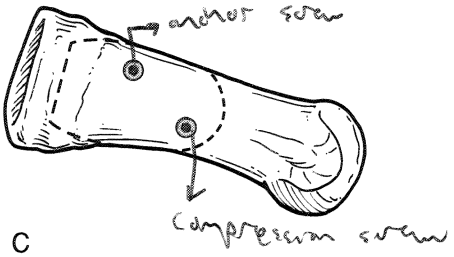

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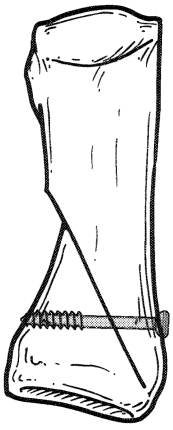

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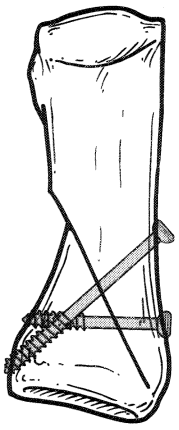

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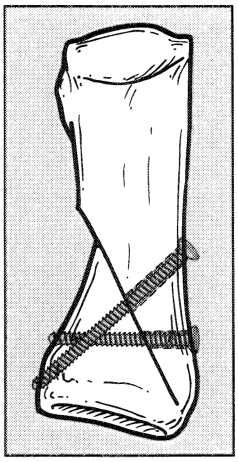


F

III. OBLIQUE SCREW ORIENTATIONS

III.D.1. DFWO / "T"- SLEEVE TECHNIQUE

Technique: - ***"Standard" cortical "Lag" technique***
- 1 screw / 3.5 mm cortical screw

PURPOSE:
- additional technique for oblique osteotomies
  using the "T" sleeve technique *("Standard fragment" lag technique)*
  to prevent the initial drill *(thread hole)* from sliding down the internal cortex

POINTS OF INSTRUCTION:
- Axis guide, plantar-proximal aspect of the metatarsal base / horizontal orientation
- cut osteotomy, proximal cut 1st, distal cut 2nd
  (proximal cut dictates orientation of screw to final osteotomy)
- reduce and clamp
- general screw orientation / half-way between perpendiculars

"Standard" - Lag Screw Technique with "T" sleeve - 3.5 mm cortical screw

** Keep same orientation of all of the instrumentation used in the following fixation sequences

- over-drill 3.5 mm drill bit **(PROXIMAL CORTEX ONLY!!!)** ***(fig. A)***

- "T" sleeve 3.5 mm outside / 2.5 mm inside *(inserted to the distal cortex)* ***(fig. B)***
inserted to control point of exit of the thread hole through the distal cortex
prevents sliding of the 2.5 mm drill bit down the inside of the far cortex
* *serrated tip of the drill sleeve engages the distal cortex and prevents movement or migration of the thread drill as it attempts to penetrate the distal cortex*

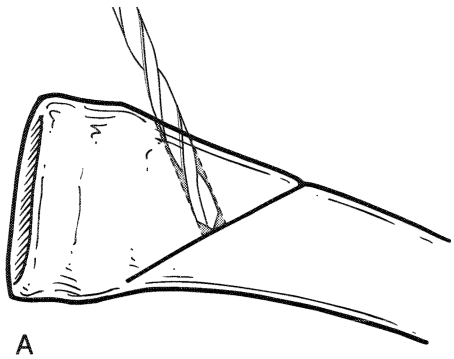
- thread hole 2.5 mm drill (through distal cortex) ***(fig. B)***
(complete thread hole through the distal cortex with the use of the "T" sleeve to prevent internal sliding and fracture of the drill bit)

- countersink *(increases contact surface and reduces chance of stress riser)* ***(fig. C)***

- depth gauge *(measure the "distal" side of the hole to get accurate length)* ***(fig. D)***

- tap 3.5 mm cortical tap *(1.25 mm pitch)* ***(fig. E)***

- insert screw 3.5 mm cortical screw ***(fig. F)***



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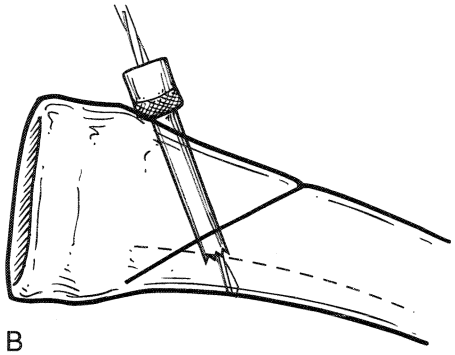

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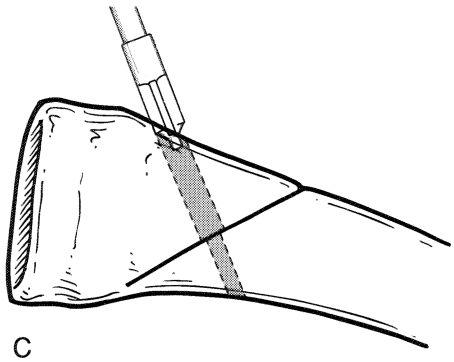

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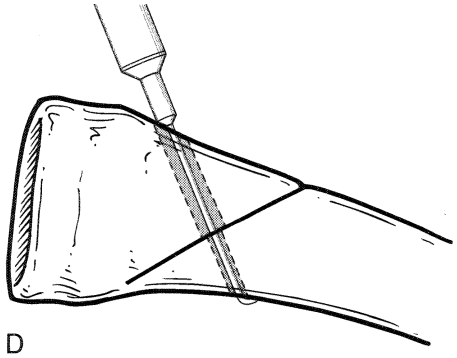

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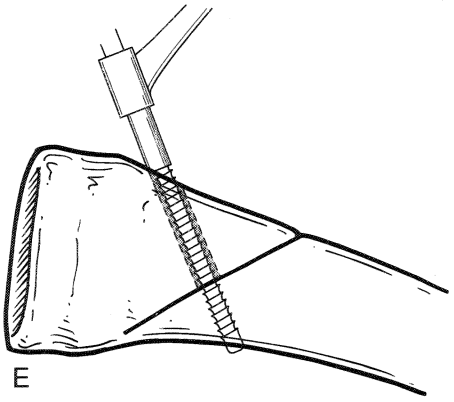

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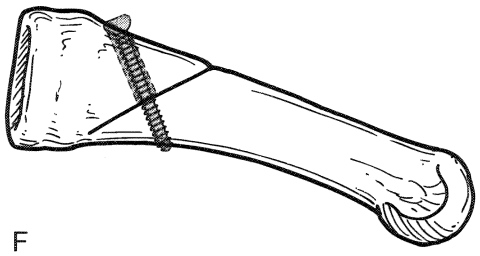


F

III. OBLIQUE SCREW ORIENTATIONS

III.D.2. NUANCES OF OBLIQUE SCREW INSERTION

PURPOSE:

An oblique angle of screw insertion can create specific technical difficulties in the screw insertion process.

Thin "Thread" drills can skip along the external and internal cortices of the bone. ***(fig. A)***

The use of the "T" sleeve can control the angle of the thread drill and point of penetration of the internal or far cortex ***(fig. B)***

If the SFS countersink (2.5 mm tip) is used as prescribed in the "Standard" Cortical Lag Technique, the countersink is used after creation of the primary "glide hole" (3.5 mm)

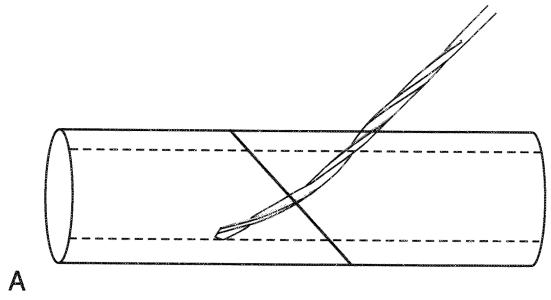
In an "oblique" insertion, the countersink will shift to the far side of the "glide hole" and the resulting countersink will be "off center" from the true path of the screw.

This mechanical "mal-alignment" can create shift of the head and shaft of the screw as it contacts the near cortex and result in a stress riser or splitting of the proximal cortex as the head of the screw shifts to seat itself into the countersink in the bone. ***(fig. C)***

This specific technical difficulty can be avoided by altering the insertion sequence by creating the "thread hole" initially followed by use of the countersink. ***(fig. D)***

The 2.5 mm thread hole will control the positioning of the countersink in a true "concentric" alignment.

The "Over drill" or "Glide hole" can then be created after use of the countersink.



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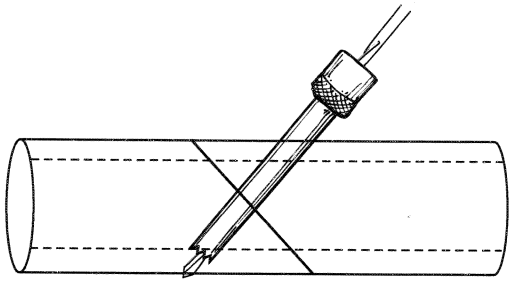

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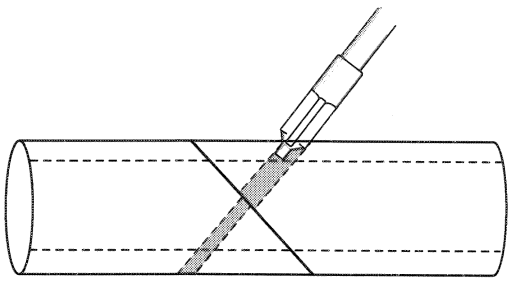

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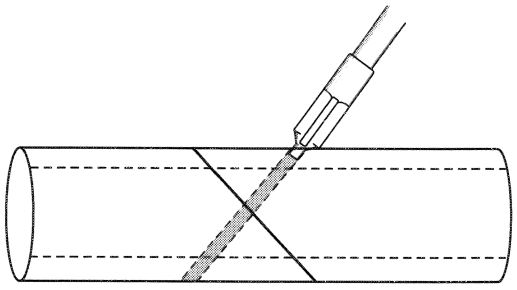


D

III. OBLIQUE SCREW ORIENTATIONS

III.D.3. DFWO / "T"- SLEEVE TECHNIQUE / "MODIFIED" TECHNIQUE

Technique: *- **"Modified" "Standard" cortical screw "Lag" technique***
- 1 screw / 3.5 mm cortical screw

PURPOSE:

Modification of the "Standard" technique to accurately control the drills and direction of the screw along with proper positioning of the countersink when inserting screws obliquely to the near and far cortices

POINTS OF INSTRUCTION:

Modification

pre-drill** 0.062 / 1.6mm K-wire ***(fig. A)
(allows for fine control of the drill hole through dorsal and plantar cortices)

thread hole** 2.5 mm drill **(PROXIMAL CORTEX ONLY !!!)** ***(fig. B)
(so that countersink will be concentric with overall insertion technique)

- countersink *(will now be concentric with overall fixation sequence)* ***(fig. C)***

* countersinking must be done after use of the 2.5 mm drill because the tip of the countersink is 2.5 mm

If countersinking is done after creating the "glide hole" the tip of the countersink (especially in oblique orientations) can shift off-line and create an "off-center" countersink which will cause the screw to shift as the head of the screw engages the near cortex and attempts to seat in the countersink.
This shift can create a split or stress riser in the near cortex.

Continuation of "Standard" Lag Technique

- over-drill 3.5 mm drill bit **(PROXIMAL CORTEX ONLY!!!)** ***(fig. D)***

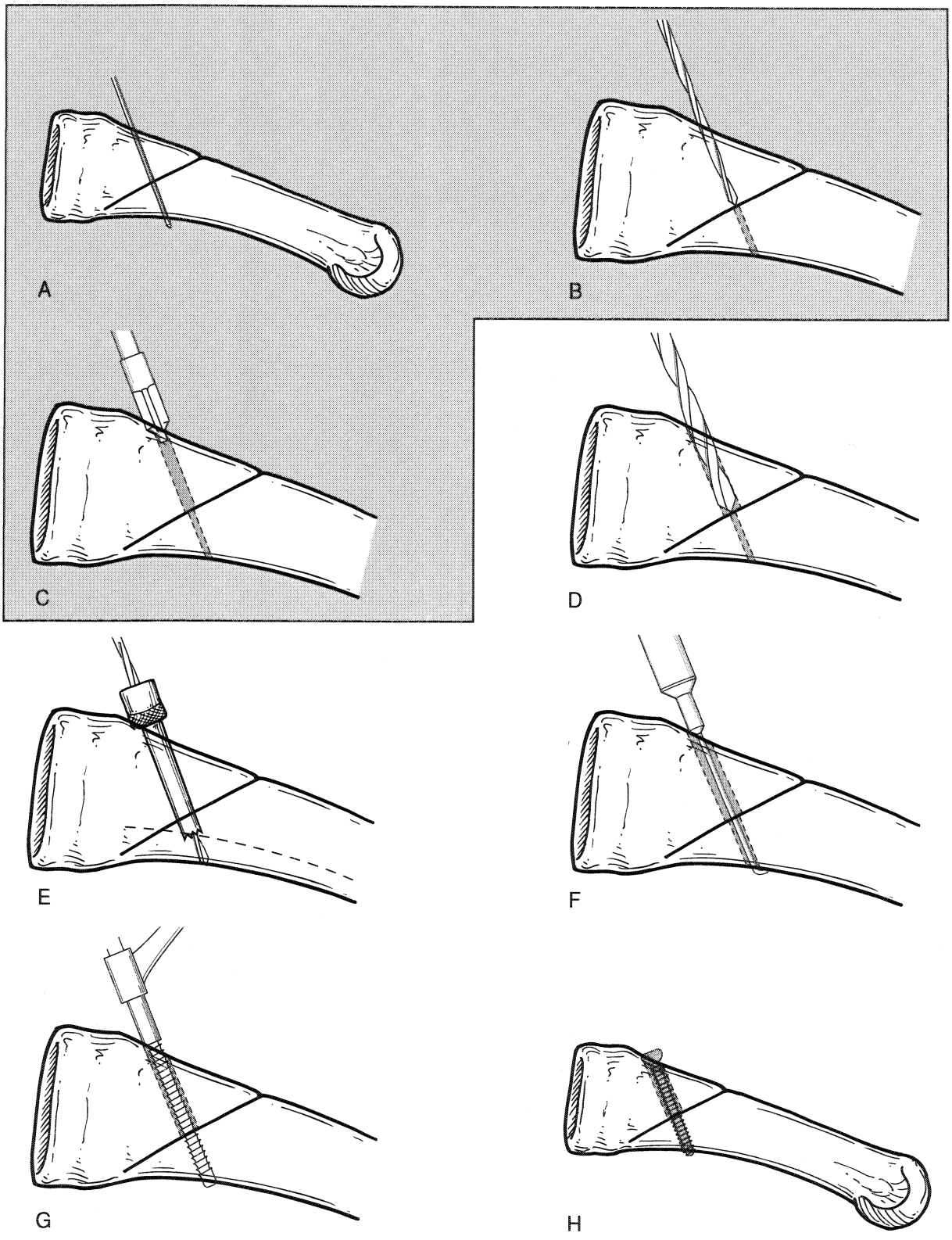
- "T" sleeve 3.5 mm outside / 2.5 mm inside *(inserted to the distal cortex)* ***(fig. E)***

- thread hole 2.5 mm drill *(through distal cortex)* ***(fig. E)***

- depth gauge ***(fig. F)***

- tap 3.5 mm cortical tap *(1.25 mm pitch)* ***(fig. G)***

- insert screw 3.5 mm cortical screw ***(fig. H)***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IV. HALLUX VALGUS OSTEOTOMIES

IV.A. CHEVRON OSTEOTOMIES

IV.A.1. AUSTIN

Technique: *- axis guide, osteotomy technique, fixation of the plantar arm*
- 3.0 mm cannulated "headless" screw

IV.A.2. LONG DORSAL ARM - HALLUX VALGUS

Technique: *- axis guide, osteotomy technique, fixation of the long dorsal arm*
- 2 screws / 2.7 mm cortical screws

IV.A.3. LONG PLANTAR ARM - HALLUX VALGUS

Technique: *- axis guide, osteotomy technique, fixation of the long plantar arm*
- 2 screws / 2.7 mm cortical screws

IV.A.4. LONG PLANTAR ARM - TAILOR'S BUNION

Technique: *- axis guide, osteotomy technique, fixation of the long plantar arm*
- 2 screws / 2.0 mm cortical screws

IV. HALLUX VALGUS OSTEOTOMIES

IV.A.1. AUSTIN

Technique: *- axis guide, osteotomy technique, fixation of the plantar arm*
- 3.0 mm cannulated "headless" screw

PURPOSE:
- compression screw fixation of the plantar arm of a "Chevron" osteotomy
- use of the 3.0 mm "headless" screw

POINTS OF INSTRUCTION:
Axis guide *(dictates length and/or sagittal displacement with lateral shift of the metatarsal head)*
Osteotomy technique *(Displace capital fragment laterally 4 mm / Temporary Fixation with K-wire)*

3.0 mm "headless" screw - Insertion Technique

- **guide wire** 1.1 mm (threaded or non-threaded) ***(fig. A)***

- **external measuring device** (placed over guide wire) *subtract 2 mm ***(fig. B)***

- **cannulated drill bit 2.0 mm** (with double drill sleeve) ***(fig. C)***

- pick up appropriate 3.0 mm "headless" screw with compression sleeve and sleeve handle

- insert the screw and driver complex over the guide wire

- engage dorsal cortex and thread the screw into the bone by turning the compression sleeve / handle until the "land" of the compression sleeve engages the dorsal cortex and compresses the osteotomy ***(fig. D, E)***

- remove the handle from the compression sleeve

- insert cannulated "star drive" screwdriver into the compression sleeve and engage "headless" screw *(screwdriver will align the "green" laser marking to the compression sleeve)*

- rotate and advance the screw out of the compression sleeve and into the dorsal cortex ***(fig. E)***

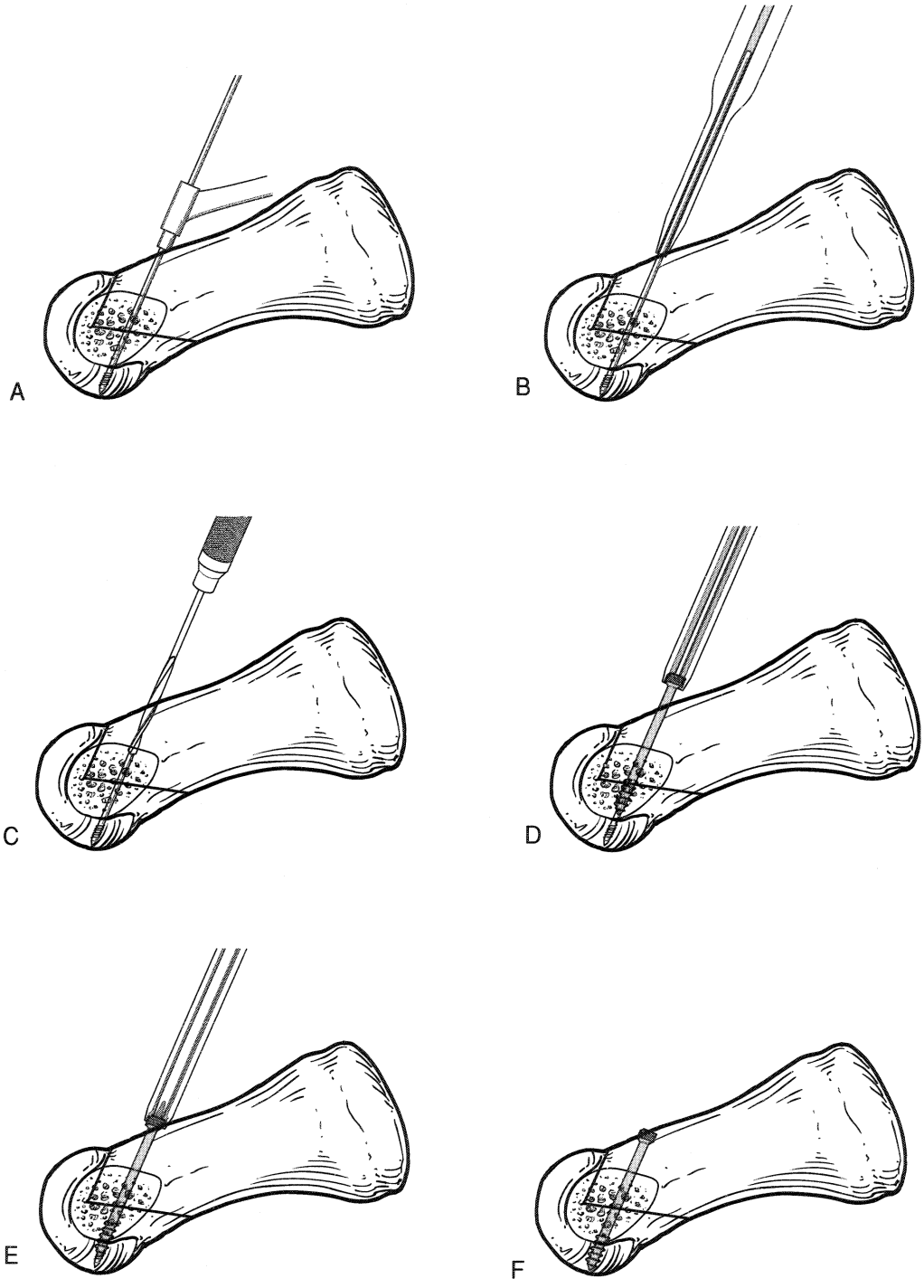
!! secure the compression sleeve to prevent rotation while rotating the screwdriver
(rotate and advance the "headless" screw into the bone until the the "yellow" laser marking matches the proximal edge of the compression sleeve)

* at this point, the head of the screw should be disengaged from the sleeve and engaged into the bone

- the screw can be advanced an additional 2 mm and further recessed into the bone by rotating the screwdriver until the "red" laser marking

* *remove guide wire* ***(fig. F)***

- other screws can be used for fixation of the plantar arm including 2.4 mm and 2.7mm cortical screws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IV. HALLUX VALGUS OSTEOTOMIES

IV.A.2. LONG DORSAL ARM - HALLUX VALGUS

Technique: *- axis guide, osteotomy technique, fixation of the long dorsal arm*
- 2 screws / 2.7 mm cortical

PURPOSE:

- fixation of the dorsal arm of a "long dorsal arm" Chevron osteotomy

POINTS OF INSTRUCTION:

- same axis guide principles
- osteotomy / dorsal cut exits proximal to midshaft of 1st metatarsal ***(fig. A)***
  to allow for insertion of 2 screws in the dorsal fragment

Temporary Fixation Technique:

- "temporary" fixation pin inserted away from intended points of insertion of the fixation screws ***(fig. A)***

- insert (2) 1.6 mm K-wires perpendicular to the osteotomy ***(fig. A)***
  as "pre-drill" sites for insertion of the compression screws

- insert (2) 2.7 mm screws, dorsal to plantar... ***(fig. B, C, D)***

Insertion Sequence - 2.7 mm cortical screw ("small bone" Lag technique)

- pre-drill 1.6 mm K-wire

- thread hole 2.0 mm drill bit

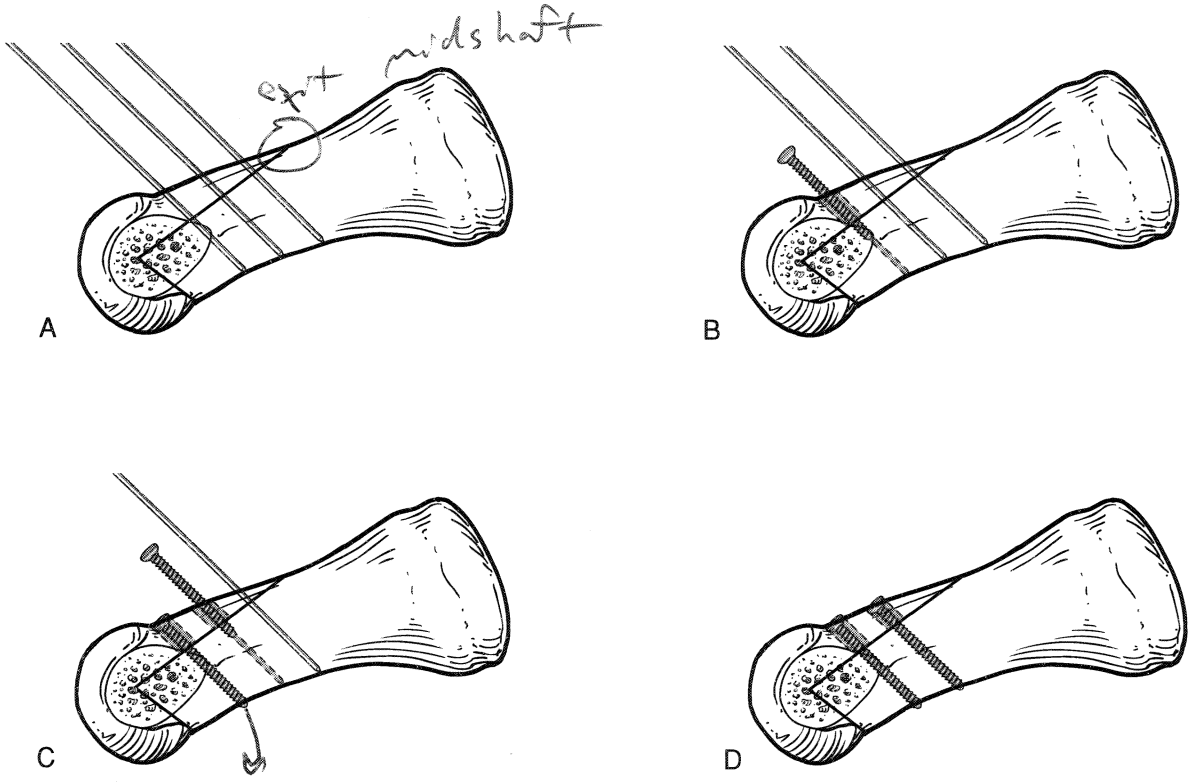
- countersink *"mini" fragment set countersink (2.0 mm tip)*

- depth gauge

- tap 2.7 mm cortical tap

- overdrill 2.7 mm drill bit

- screw insertion 2.7 mm cortical screw



want to exit 4-5 mm from plantar cut

IV. HALLUX VALGUS OSTEOTOMIES

IV.A.3. LONG PLANTAR ARM - HALLUX VALGUS

Technique: *- axis guide, osteotomy technique, fixation of the long plantar arm*
- 2 screws / 2.7 mm cortical

PURPOSE:

- fixation of the plantar arm of a "long plantar arm" Chevron osteotomy

POINTS OF INSTRUCTION:

- same axis guide principles
- osteotomy / plantar cut exits proximal to midshaft of 1st metatarsal ***(fig. A)***
  to create a long plantar arm of the osteotomy and accommodate insertion of 2 screws

Temporary Fixation Technique:

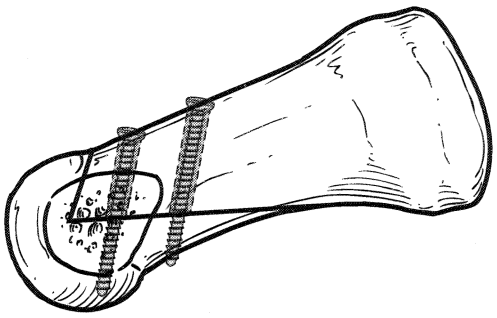
- "temporary" fixation pin inserted or osteotomy secured with bone clamp

- insert (2) 1.6 mm K-wires perpendicular to osteotomy for site of insertion of compression screws

- insert (2) 2.7 mm screws, dorsal to plantar... ***(fig. A, B)***

Insertion Sequence - 2.7 mm cortical screw ("small bone" Lag technique)

- pre-drill	1.6 mm K-wire
- thread hole	2.0 mm drill bit
- countersink	
- depth gauge	
- tap	2.7 mm cortical tap
- overdrill	2.7 mm drill bit
- screw insertion	2.7 mm cortical screw



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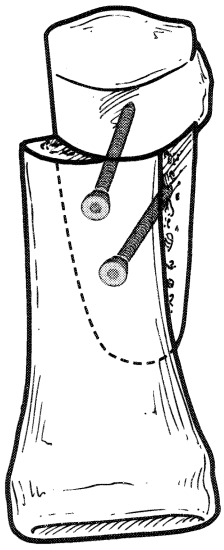


B

IV. HALLUX VALGUS OSTEOTOMIES

IV.A.4. LONG PLANTAR ARM - TAILOR'S BUNION

Technique: *- axis guide, osteotomy technique, fixation of the long plantar arm*
- 2 screws / 2.0 mm cortical screws

PURPOSE:

- fixation of the plantar arm of a "long plantar arm" Chevron osteotomy

POINTS OF INSTRUCTION:

- same axis guide principles
- osteotomy / plantar cut exits more proximally on the plantar shaft of the 5th metatarsal to create a long plantar arm of the osteotomy and allow for insertion of 2 screws ***(fig. A)***

Temporary Fixation Technique:

- insert (2) 1.6 mm K-wires perpendicular to osteotomy ***(fig. A, B)*** for site of insertion of compression screws

- withdraw one fixation pin and insert a 2.0 mm cortical screw

- withdraw the second fixation pin and insert the second 2.0 mm cortical screw

Insertion Sequence - 2.0 mm cortical screw ("small bone" Lag technique)

- pre-drill 0.045 K-wire

- thread hole 1.5 mm drill bit

- countersink

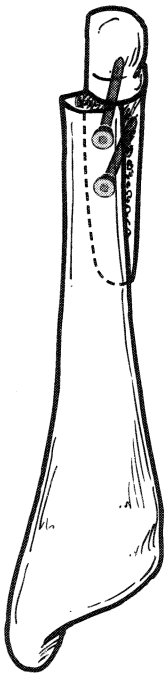
- depth gauge

- tap 2.0 mm cortical tap

- overdrill 2.0 mm drill bit

- screw insertion 2.0 mm cortical screw

A



B

IV. HALLUX VALGUS OSTEOTOMIES

IV.B. "SCARF" OSTEOTOMIES

IV.B.1. "TRADITIONAL" SCARF

Technique: *- axis guides / "Z" osteotomy techniques*
- 2.7 mm cortical screws

IV.B.2. "INVERTED" SCARF

Technique: *- axis guides / "Z" osteotomy technique*
- 2.7 mm cannulated "headless" screw

IV.B.3. SCARF OSTEOTOMY / SAGITTAL "Z" / PLANTARFLEXION

Technique: *- Sagittal "Z" osteotomy technique / Rotation*
- 2.7 mm cortical screws

IV.B.4. SCARF OSTEOTOMY / SAGITTAL "Z" / LENGTHENING

Technique: *- Sagittal "Z" osteotomy technique / Slide Lengthening / Bone Graft*
- 2.7 mm cortical screws

IV. HALLUX VALGUS OSTEOTOMIES

IV.B.1. "TRADITIONAL" SCARF

(more susceptible to fracture through proximal cut)

Technique: *- axis guides / "Z" osteotomy techniques*
- 2.7 mm cortical screws

PURPOSE:

- technique of a "Traditional Scarf" osteotomy, axis guides, (3) cuts
- fixation of the "Scarf" osteotomy

POINTS OF INSTRUCTION:

- (2) axis pins

"Traditional" "Z" cut

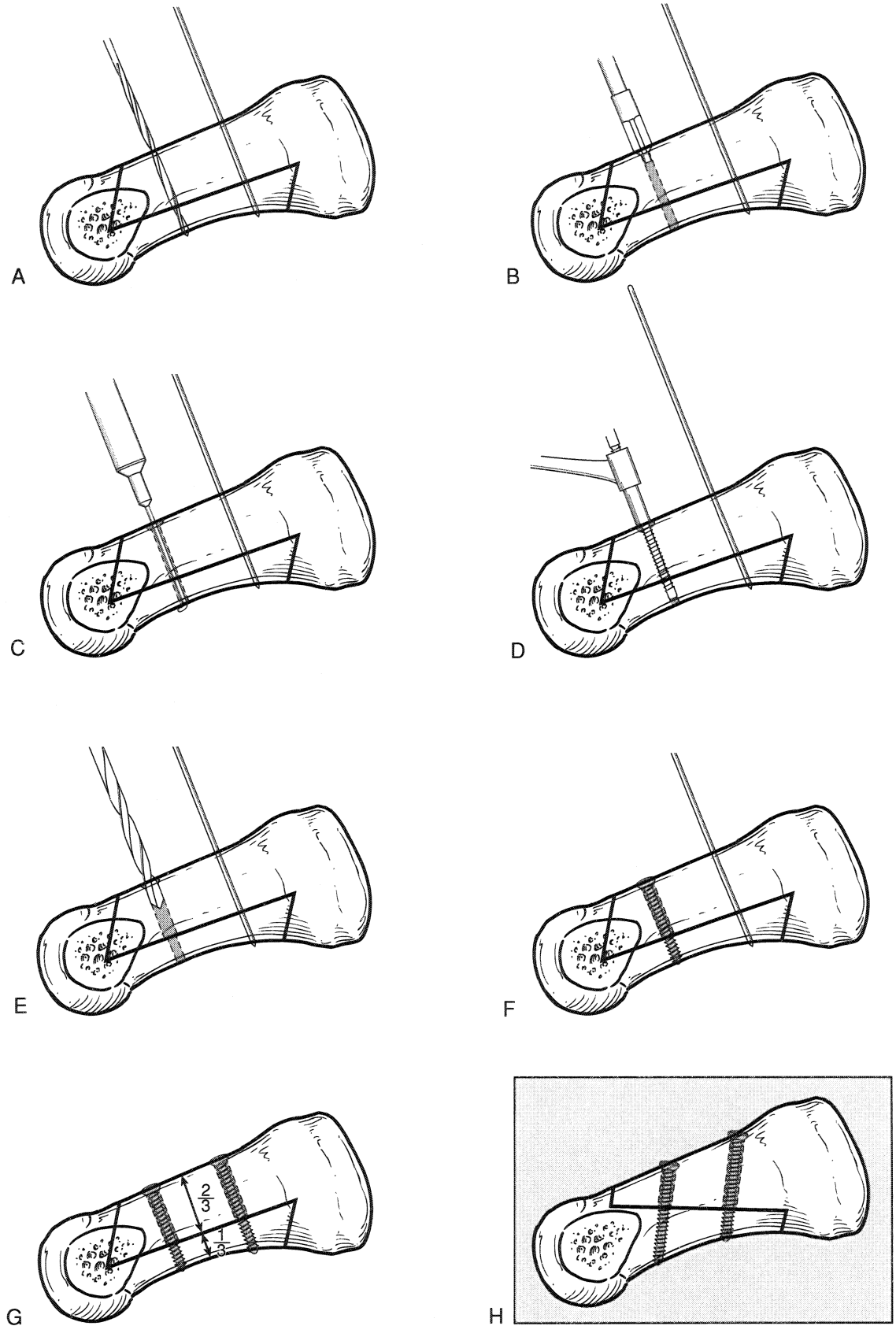
- primary cut / horizontal *(2/3 dorsal vs. 1/3 plantar)*
- secondary cuts
  - distal / dorsal
  - proximal / plantar
- displace the plantar segment laterally and secure with a bone clamp

- insert (2) 2.7 mm screws, dorsal to plantar

Insertion Sequence - 2.7 mm cortical screw ("small bone" Lag technique)

- pre-drill	1.6 mm K-wire
- thread hole	2.0 mm drill bit
- countersink	
- depth gauge	
- tap	2.7 mm cortical tap
- overdrill	2.7 mm drill bit
- screw insertion	2.7 mm cortical screw

** **Osteotomy Modification** ***(fig. H)***
horizontal orientation of long mid-shaft osteotomy similar to a Mau osteotomy utilizing short distal and proximal cut-outs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G
2/3
1/3
H

IV. HALLUX VALGUS OSTEOTOMIES

IV.B.2. "INVERTED" SCARF

Technique: *- axis guides / "Z" osteotomy techniques*
- 2.7 mm cortical screws

PURPOSE:

- technique of a "Scarf" osteotomy, axis guides, (3) cuts
- fixation of the "Scarf" osteotomy

POINTS OF INSTRUCTION:

- (2) axis pins ***(fig. A)***

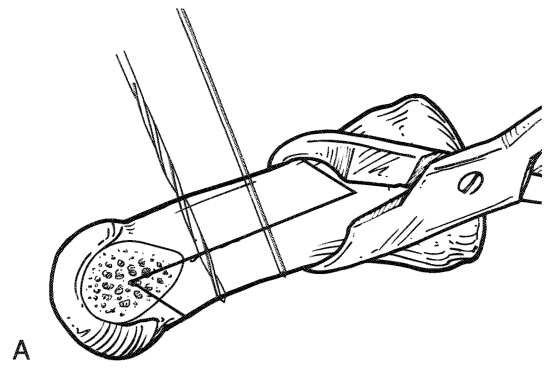
"Inverted" "Z" cut, (not susceptible to fracture through proximal cut) ***(fig. A)***

- primary cut / horizontal
- secondary cuts
  - distal / plantar
  - proximal / dorsal
- displace the dorsal segment laterally and secure with a bone clamp ***(fig. A)***

✱ Insert (2) 2.7 mm cortical screws, dorsal to plantar

Insertion Sequence - 2.7 mm cortical screw ("small bone" Lag technique)

- pre-drill	1.6 mm K-wire	***(fig. A)***
- thread hole	2.0 mm drill bit	***(fig. A)***
- countersink		***(fig. B)***
- depth gauge		***(fig. C)***
- tap	2.7 mm cortical tap	***(fig. D)***
- overdrill	2.7 mm drill bit	***(fig. E)***
- screw insertion	2.7 mm cortical screw	***(fig. F, G)***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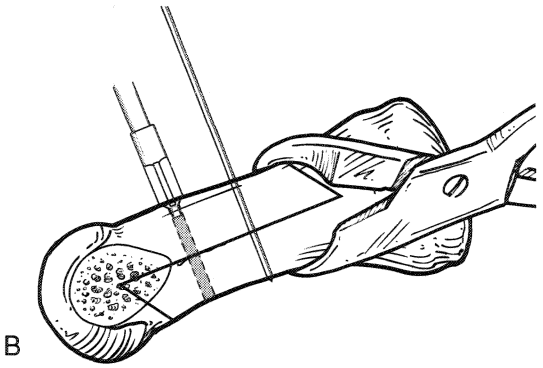
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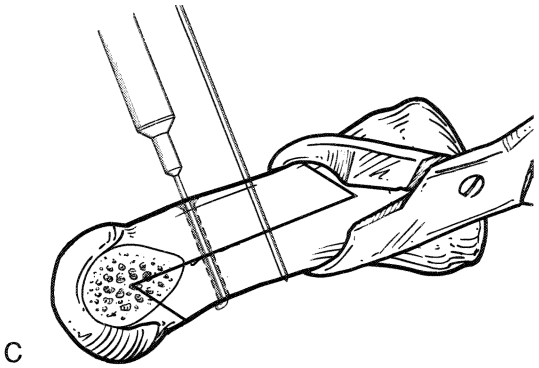
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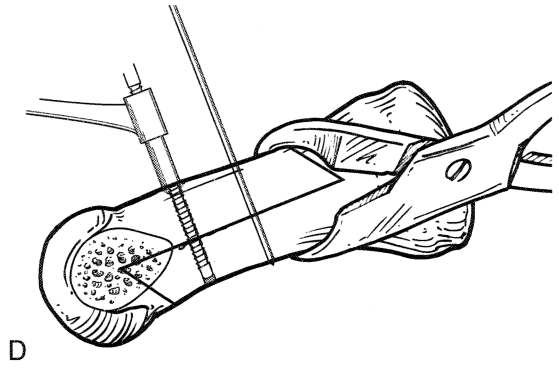
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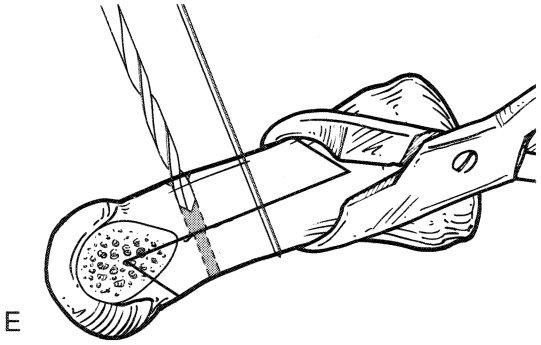
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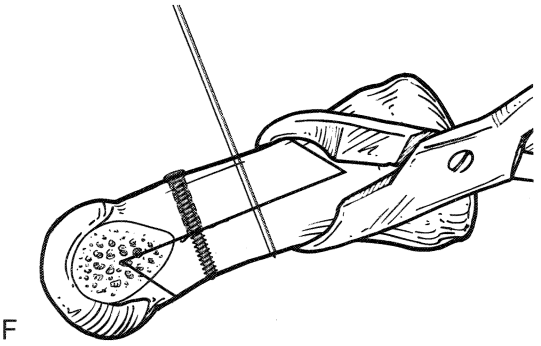
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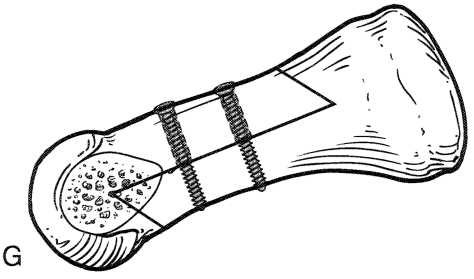

G

IV. HALLUX VALGUS OSTEOTOMIES

IV.B.3. SCARF OSTEOTOMY / SAGITTAL "Z" / PLANTARFLEXION

Technique: *- Sagittal "Z" osteotomy technique / Rotation*
- 2.7 mm cortical screws

PURPOSE:

- technique of a Sagittal "Z" osteotomy, axis guides, (3) cuts to plantarflex a metatarsal
- fixation of the Sagittal "Z" osteotomy

POINTS OF INSTRUCTION:

- (2) axis pins

"Sagittal" "Z" cut ***(fig. A)***

- primary cut / sagittal
- secondary cuts
  - distal / lateral
  - proximal / medial
- rotate medial segment in plantar direction ***(fig. B)***
- secure with bone clamp

- insert (2) 2.7 mm screws, medial to lateral ***(fig. A, B)***

Insertion Sequence - 2.7 mm cortical screw ("small bone" Lag technique)

- pre-drill 1.6 mm K-wire

- thread hole 2.0 mm drill bit

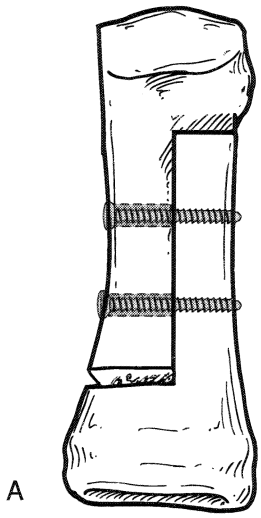
- countersink

- depth gauge

- tap 2.7 mm cortical tap

- overdrill 2.7 mm drill bit

- screw insertion 2.7 mm cortical screw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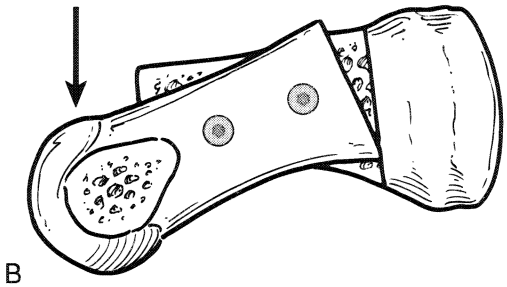
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IV. HALLUX VALGUS OSTEOTOMIES

IV.B.4 SCARF OSTEOTOMY / SAGITTAL "Z" / LENGTHENING

Technique: *- Sagittal "Z" osteotomy technique / Slide Lengthening / Bone Graft*
- 2.7 mm cortical screws

PURPOSE:

- technique of a Sagittal "Z" osteotomy, axis guides, (3) cuts to lengthen a metatarsal
- fixation of the Sagittal "Z" osteotomy

POINTS OF INSTRUCTION:

- (2) axis pins

"Sagittal" "Z" cut ***(fig. A)***

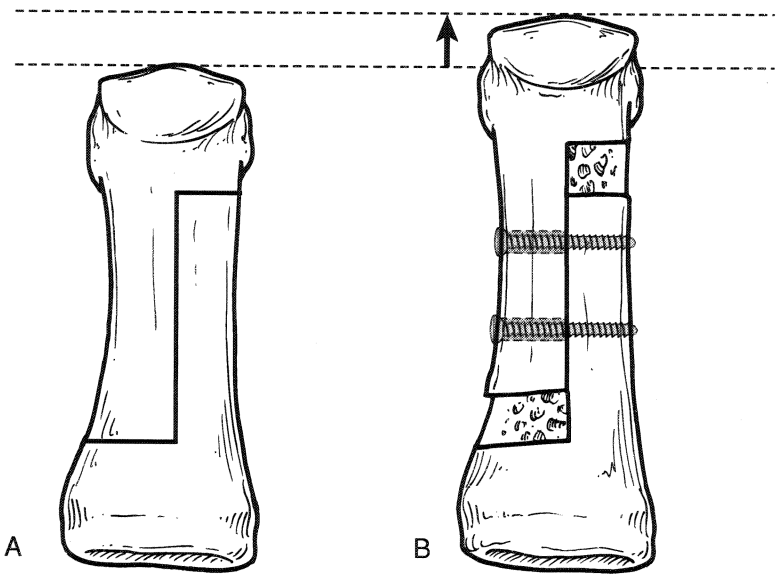
- primary cut / sagittal
- secondary cuts
  - distal / lateral
  - proximal / medial
- distract the medial distal segment approximately 1 cm ***(fig. B)***
- secure with bone clamp

- insert (2) 2.7 mm screws, medial to lateral ***(fig. B)***

Insertion Sequence - 2.7 mm cortical screw ("small bone" Lag technique)

- pre-drill	1.6 mm K-wire
- thread hole	2.0 mm drill bit
- countersink	
- depth gauge	
- tap	2.7 mm cortical tap
- overdrill	2.7 mm drill bit
- screw insertion	2.7 mm cortical screw

**** insert cancellous bone graft to fill deficits created by slide lengthening of the osteotomy*


A
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V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

1ST RAY ARTHRODESIS

V.A. HALLUX IPJ FUSION

V.B. 1ST MPJ ARTHRODESIS

V.C.1. LAPIDUS (HAV) / "SEATTLE" TECHNIQUE / CORTICAL SCREWS

V.C.2. LAPIDUS (HAV) / "TUCKER" TECHNIQUE / CANCELLOUS SCREWS

REARFOOT FUSIONS

V.D.1.a. SUBTALAR JOINT - "SUPERIOR APPROACH"

V.D.1.b. SUBTALAR JOINT - "INFERIOR APPROACH"

V.D.2. TALONAVICULAR JOINT

V.D.3. CALCANEAL - CUBOID JOINT

V.D.4 TRIPLE ARTHRODESIS - ***combined fusion of ST, TN and CC joints***

ANKLE FUSIONS

V.E.1. "TRIPOD" SCREW TECHNIQUES

V.E.1.a. POSTERIOR - MEDIAL "HOME RUN" SCREW

V.E.1.b. POSTERIOR - LATERAL "HOME RUN" SCREW

V.E.2. "TUCKER" TECHNIQUE

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

1st RAY ARTHRODESIS

V.A. HALLUX IPJ FUSION

Technique: *- single screw*
- 4.0 mm cancellous screw / partially or fully threaded

V.B. 1ST MPJ ARTHRODESIS

Technique: *- crossed screws*
- 4.0 mm cancellous screws

V.C.1. LAPIDUS (HAV) / "SEATTLE" TECHNIQUE / CORTICAL SCREWS

Technique: *- crossed screws / 4.0 mm cortical screws*

V.C.2. LAPIDUS (HAV) / "TUCKER" TECHNIQUE / CANCELLOUS SCREWS

Technique: *- crossed screws / 4.0 mm cannulated cancellous screws*

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.A. HALLUX IPJ FUSION

Technique: *a. 4.0 mm "partially threaded" cancellous screw*
b. 4.0 mm "fully threaded" cancellous screw

PURPOSE:

Single screw fixation of the hallux IPJ arthrodesis *(partially or fully threaded cancellous screws)*

POINTS OF INSTRUCTION:

*cut across the hallux IPJ of the bone model ***(fig. A)***

Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- thread hole 2.5 mm drill (fig. A)
- drill initially from the center of the base of the distal phalanx, exit out through central aspect of the tip of the distal phalanx
REMOVE the 2.5 mm drill from the distal phalanx

- align the distal and proximal phalangeal surfaces with flush contact and anatomic alignment. Maintain this alignment for completion of the thread hole. ***(fig. B)***

- re-insert the 2.5 mm thread drill into the distal tip of the distal phalanx and drill across the interphalangeal joint back into the proximal phalanx ***(fig. B)***
- remove the 2.5 mm drill bit

- countersink *(keep in line with thread hole)* ***(fig. C)***
- depth gauge select a screw that is just short of the full length measured ***(fig. D)***

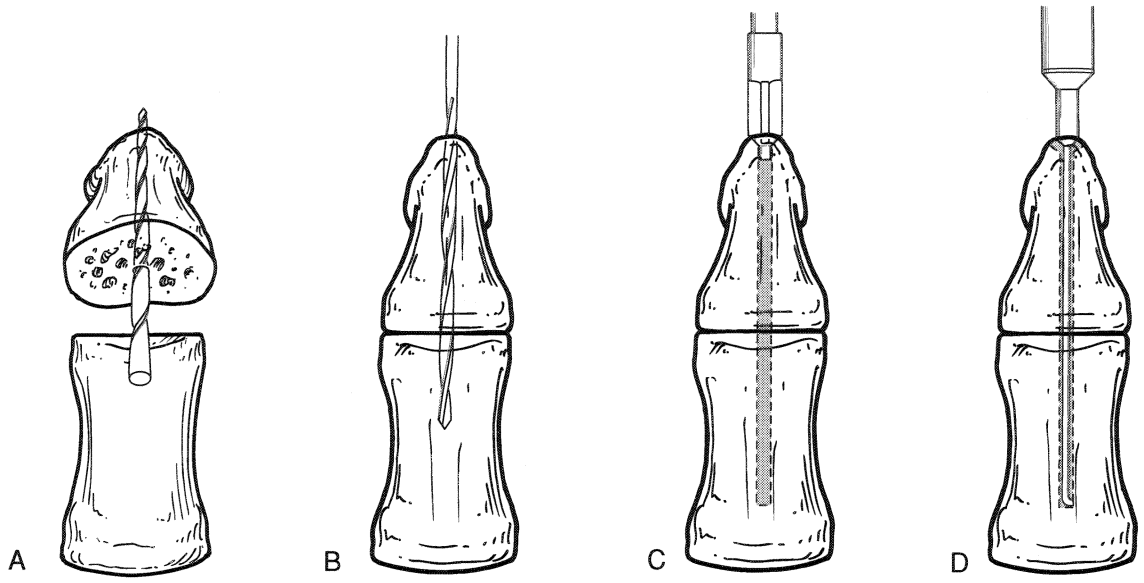
tap** 4.0 mm cancellous tap *(1.75 mm pitch)* ***(fig. E)
* *Tapping of the two phalangeal bones should be done separately*
- tap the full length of the distal phalanx and remove
- tap the distal 1 cm of the proximal phalanx separately from the distal phalanx
* *this maneuver will avoid potential fracture of the tap while trying to tap two unstable fragments of bone at the same time*

- re-approximate the surfaces of the interphalangeal joint.

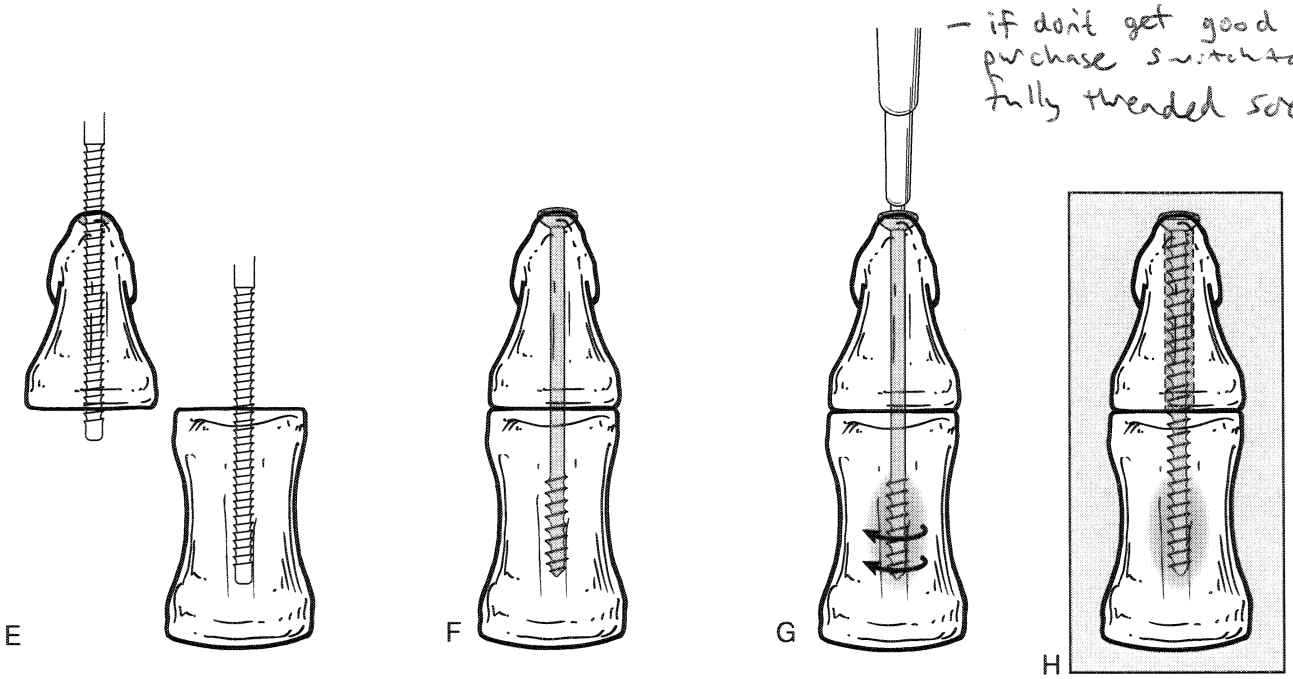
- screw insertion 4.0 mm "partially threaded" cancellous screw ***(fig. F)***

** If the partially threaded cancellous screw has poor purchase because of soft bone at the proximal end of the bone... ***(fig. G)***
Remove the partially threaded cancellous screw,
Overdrill the distal phalanx with a 4.0 mm drill bit or burr and ***(fig. H)***
Insert a "fully threaded" cancellous screw ***(fig. H)***
*** *this maneuver will take advantage or denser bone at the distal aspect of the proximal phalanx for more secure thread purchase and interfragmental compression*

- want to fuse hallux with some degree of abduction



- if don't get good purchase switch to a fully threaded screw



V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.B. 1ST MPJ ARTHRODESIS

Technique: ***- crossed screws***
- 4.0 mm cancellous screws

PURPOSE:
- technique of 1st MPJ fusion with crossed screws

POINTS OF INSTRUCTION:

- cut part way through 1st MPJ *(easier to handle exercise model)*

- temporary fixation with 1.6 mm K-wires

- **1st pin** / inserted from the dorsal / medial aspect of proximal phalanx back toward ***(fig. A)***
  the dorsal / lateral aspect of metatarsal head / neck *(more dorsal plane)*

- **2nd pin** / inserted from the inferior / medial aspect of metatarsal neck, distally and laterally ***(fig. A)***
  across the joint... toward the plantar / lateral aspect of the base of the proximal phalanx
  (more plantar plane)

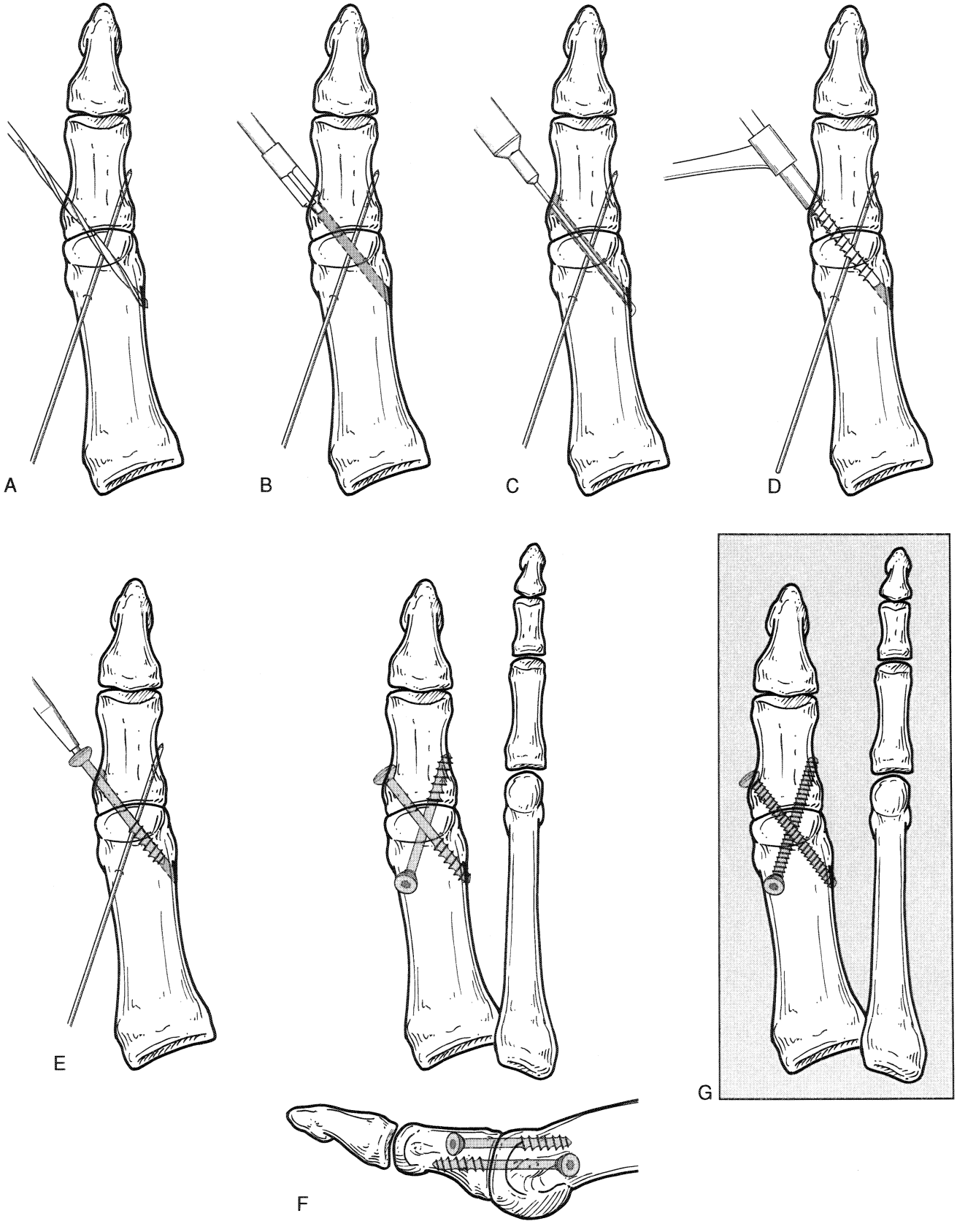
** keep planes of the screws parallel to avoid contact during insertion ***(fig. F)***

Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- pre-drill	1.6 mm K-wire	***(fig. A)***
- thread hole	2.5 mm drill bit	***(fig. A)***
- countersink	*(keep in line with thread hole)*	***(fig. B)***
- depth gauge		***(fig. C)***
- tap	4.0 mm cancellous tap *(1.75 mm pitch)*	***(fig. D)***
- screw insertion	4.0 mm "partially threaded" cancellous screw	***(fig. E, F)***

* insert distal screw first and tighten securely before inserting the proximal second screw

** *other types of screws may be used for this technique including 3.5 mm cortical screws* ***(fig. G)***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V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.C.1. LAPIDUS (HAV) / "SEATTLE" TECHNIQUE / CORTICAL SCREWS

Technique: *- **crossed screws** / 4.0 mm cortical screws*

PURPOSE:

- (2) screw fixation technique for 1st MC joint fusion (Lapidus)

- **(2) x 4.0 mm cortical screw fixation of a Lapidus (1st MC) fusion**

- make cut most of the way through the MC joint

- temporary fixation with a 1.6 mm K-wire ***(fig. A)***
  inserted dorsally (approximately 2-3 cm distal to the joint) in the central aspect of the metatarsal into plantar / medial pole of the cuneiform

- *2nd K-wire may be inserted from the dorsal mid aspect of the cuneiform, distally/plantarly into the plantar lateral aspect of the metaphysis of the metatarsal base* ***(fig. A)***

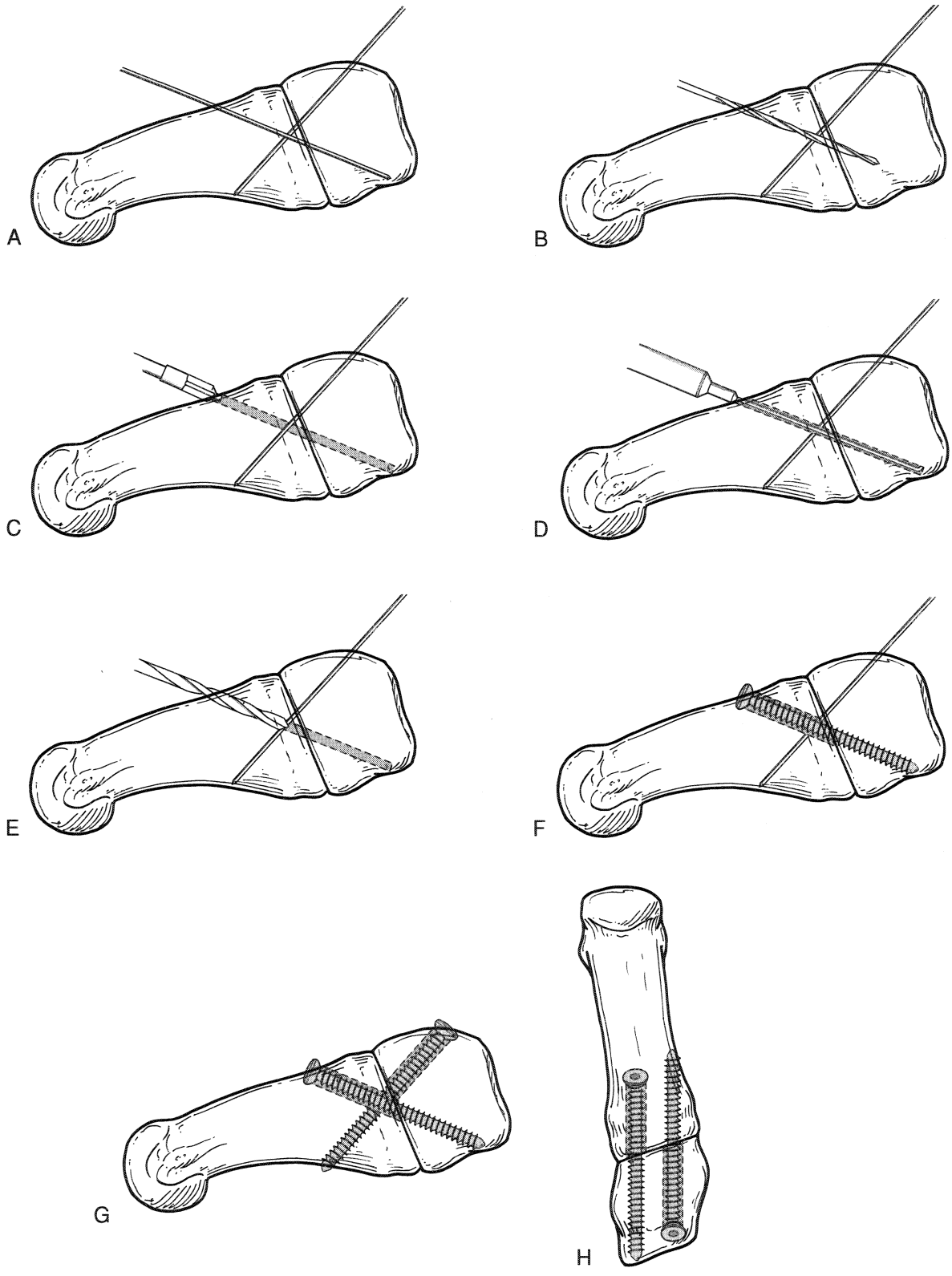
Insertion Sequence - 4.0 mm cortical screws

- thread hole	2.9 mm drill bit	***(fig. B)***
- countersink		***(fig. C)***
- depth gauge		***(fig. D)***
- overdrill	4.0 mm *(proximal cortex only)*	***(fig. E)***
- screw insertion	4.0 mm cortical screw *(self-tapping screw)*	***(fig. F, G, H)***

- 1st screw is inserted (by removing the temporary fixation pin) and then inserting the screw ***(fig. F, H)*** from the dorsal mid aspect of the metatarsal into the plantar proximal medial aspect of the cuneiform

- 2nd screw is inserted from the dorsal mid aspect of the cuneiform and directed distally/plantarly into the plantar lateral aspect of the metaphysis of the metatarsal base ***(fig. G, H)***

- screws are oriented in relatively parallel sagittal planes to each other ***(fig. H)***



50-60 mm screw

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.C.2. LAPIDUS (HAV) / "TUCKER" TECHNIQUE / CANCELLOUS SCREWS

Technique: *- **crossed screws** / 4.0 mm cannulated cancellous screws*

PURPOSE:

- (2) cannulated cancellous screw fixation technique for 1st MC joint fusion (Lapidus)

POINTS OF INSTRUCTION:

- make cut in the bone model most of the way through MC joint

- **temporary fixation**
  1.25 mm threaded tip guide wires are inserted from central dorsal aspect of metatarsal base, proximally across the metatarsal cuneiform joint into the plantar proximal aspect of the cuneiform

- **screw alignment**
- 4.0 mm cannulated cancellous screw is inserted from the plantar medial aspect of metatarsal base up into the proximal dorsal aspect of the cuneiform

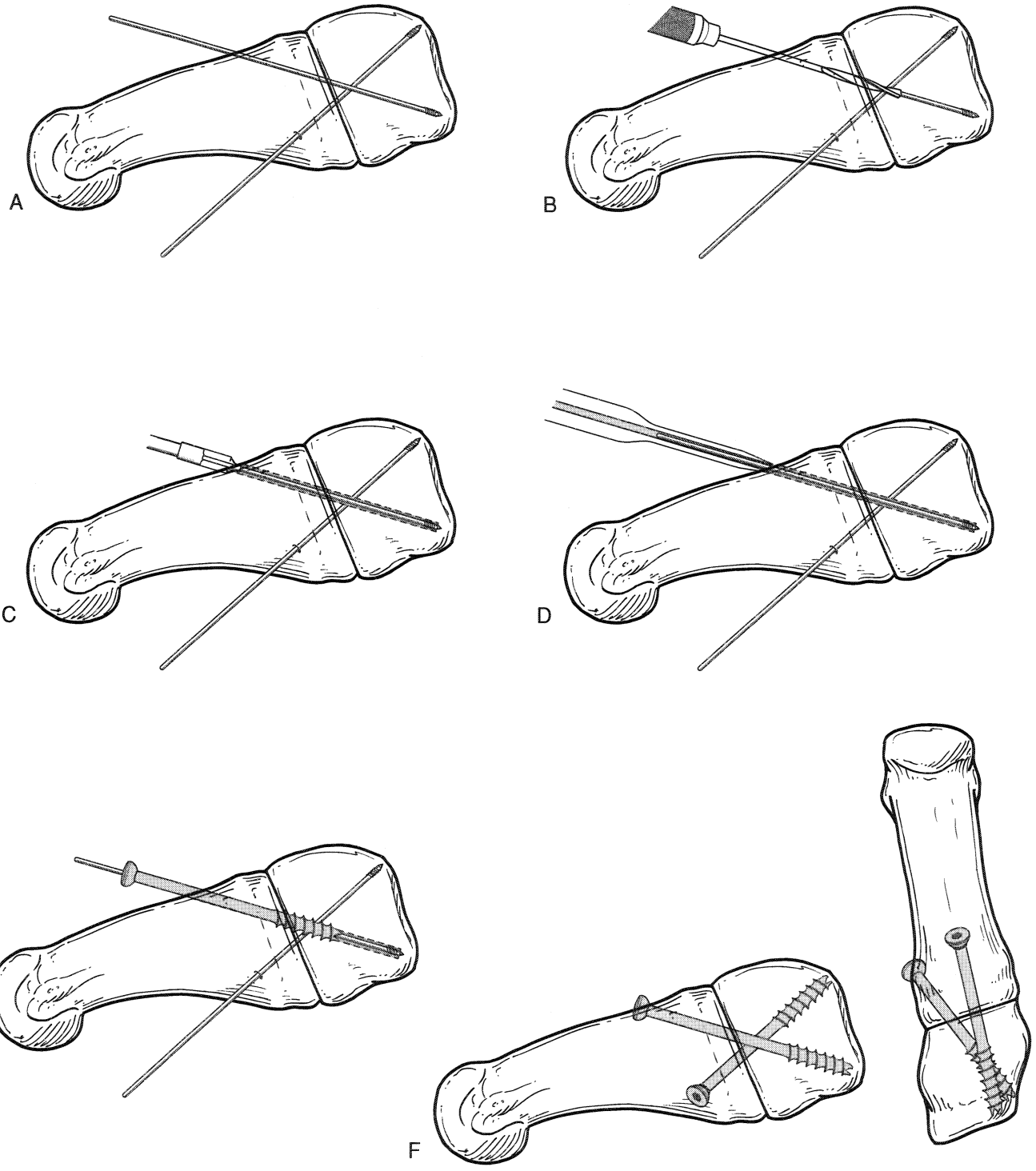
- remove guide wire before tightening of the individual screws

- insert 2nd screw (4.0 mm cannulated cancellous)

Insertion Sequence - 4.0 mm Cannulated Cancellous Screws

- guide wire	1.25 mm threaded tip guide wire	***(fig. A)***
- thread hole	**Optional drilling of proximal cortex in hard cortical bone*	***(fig. B)***
- countersink		***(fig. C)***
- external measuring device		***(fig. D)***
- *screw insertion	4.0 mm cannulated screw *(self-drilling, self-tapping)*	***(fig. E, F, G)***

**** **Non cannulated, regular 4.0 cancellous screws may also be used.***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V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

REARFOOT FUSIONS

V.D.1.a. SUBTALAR JOINT - "SUPERIOR APPROACH"

Technique: *6.5 mm large cancellous screw*

V.D.1.b. SUBTALAR JOINT - "INFERIOR APPROACH"

Technique: *7.3 mm cannulated cancellous screw*

V.D.2. TALONAVICULAR JOINT

Technique:
a. 6.5 mm large cancellous
b. 6.5 mm large cancellous + 4.0 mm "partially threaded" cancellous
c. 2 X 4.5 mm cannulated cancellous screws

V.D.3. CALCANEAL - CUBOID JOINT

Technique:
a. Distal to proximal / 6.5 mm large cancellous
b. Proximal to distal / 6.5 mm large cancellous
c. Staple fixation

V.D.4. TRIPLE ARTHRODESIS - COMBINED FUSION OF ST, TN AND CC JOINTS

Technique: *(3) x 6.5 mm large cancellous screws*

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.D.1.a. SUBTALAR JOINT - "SUPERIOR APPROACH"

Technique: *6.5 mm large cancellous screw*

POINTS OF INSTRUCTION:

- dorsal to plantar approach

- fixation is inserted from the mid neck of the talus ***(fig. F, G)***
  anterior to the articular surface of the dome of the talus
  (distal to the impaction point of the tibia on the neck talus)
  across the STJ toward the plantar-lateral-posterior corner of the calcaneus

- temporary fixation *(5/64 in. Steinmann pin)* ***(fig. A)***
*** *medial to intended insertion point for 6.5 mm cancellous screw*
* cradling the heel of the calcaneus in the palm of one hand facilitates direction of the temporary fixation pin and thread hole drill

Insertion Sequence - 6.5 mm (Large) cancellous screw (LFS)

- thread hole 3.2 mm drill bit ***(fig. A)***

overdrill** 4.5 mm drill bit **(neck of the talus ONLY !)** ***(fig. B)
(overdrill here because the tip of the countersink is 4.5 mm and the shaft of the 6.5 cancellous screw is 4.5 mm)

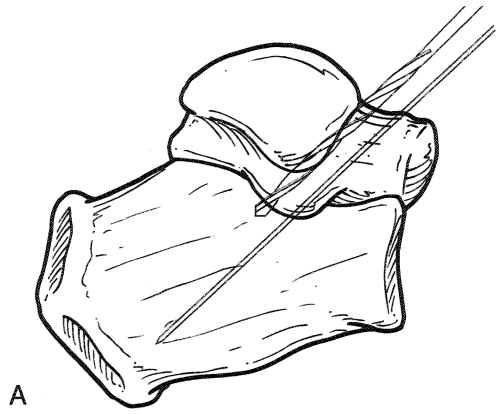
- countersink *large solid "T" countersink... has a 4.5 mm tip* ***(fig. C)***

- depth gauge measure and select a screw 5 mm short of full length ***(fig. D)***
* *recommend use of 6.5 mm screw with "long" thread pattern (32 mm)*

- tap 6.5 mm cancellous tap *(with large sleeve)* ***(fig. E)***
(forward to advance the tap, reverse to clear bone from flutes of the tap)
* *insert tap 20-25 mm short of measured length of the screw to allow the threads of the screw to press cleanly into cancellous bone*

- screw insertion 6.5 mm large cancellous screw ***(fig. F, G)***
* *recommend use of screws with "long" thread pattern (32 mm)*

** remove temporary fixation pin before final tightening of the cancellous screw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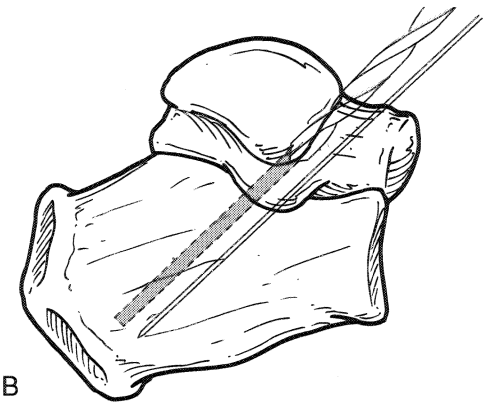
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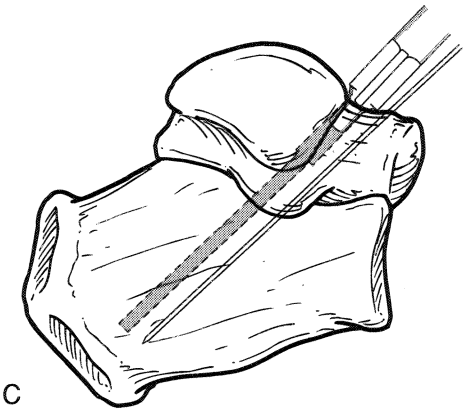
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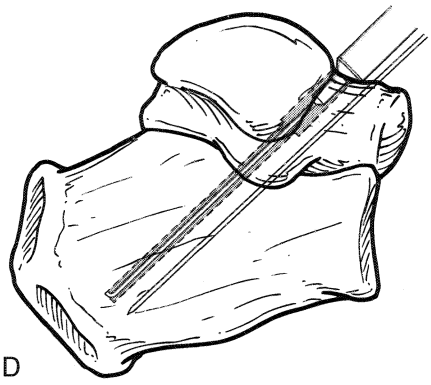
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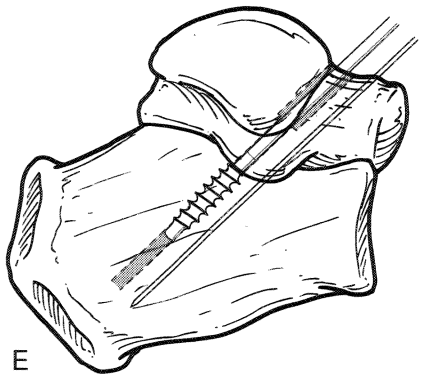
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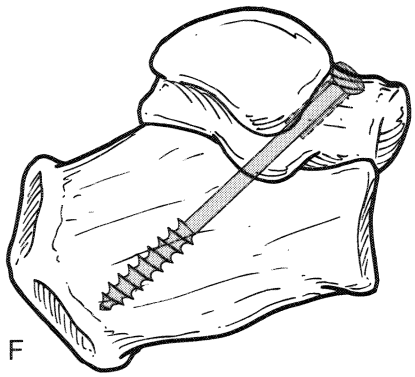
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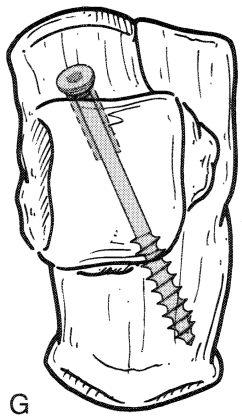

G

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.D.1.b. SUBTALAR JOINT - "INFERIOR APPROACH"

Technique: *7.3 mm cannulated cancellous screw*

POINTS OF INSTRUCTION:

Screw orientation

- from the posterior inferior aspect of calcaneus up into mid body of the talus ***(fig. F)***
  (care taken not to penetrate into the ankle joint)

Insertion Sequence - 7.3 mm cannulated cancellous screw

- guide wire 2.8 mm threaded tipped guide wire **DON'T go into the ankle joint ***(fig. A)***

- thread hole 5.0 mm drill bit **(optional)** ***(fig. B)***

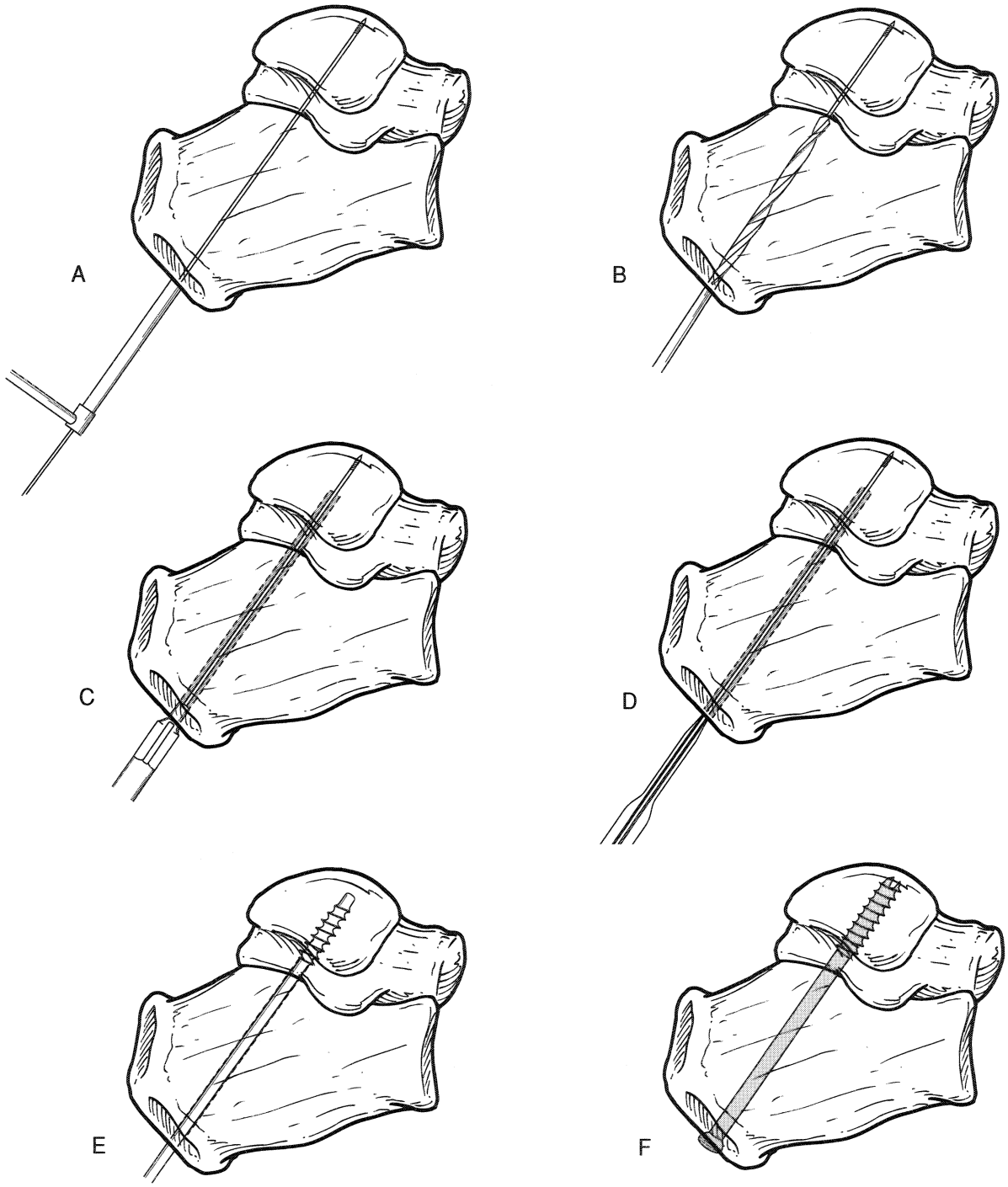
- countersink *(don't be too aggressive!)* ***(fig. C)***

- external measuring device ***(fig. D)***

tap** 7.3 mm screw is self-drilling and self-tapping **(optional)** ***(fig. E)

- screw insertion 7.3 mm cannulated screw ***(fig. F)***

***32 mm thread pattern may be used as long as the "run out" of the screw is not near the STJ*


A
B
C
D
E
F

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.D.2. TALONAVICULAR JOINT

Technique: *a. 6.5 mm large cancellous*
b. 6.5 mm large cancellous + 4.0 mm "partially threaded" cancellous
c. 2 X 4.5 mm cannulated cancellous

V.D.2.a. 6.5 MM LARGE CANCELLOUS (FIG. A)

- 5/64 in. Steinmann pin temporary fixation is inserted away from the intended site of screw placement
- screw orientation is from the plantar medial aspect of the navicular up into the neck of the talus
- insertion of 6.5 mm large cancellous screw *(with a 16 mm short thread pattern)*

Insertion Sequence - 6.5 mm cancellous screw (LFS)

- thread hole	3.2 mm drill bit
- overdrill	4.5 mm drill bit *(navicular cortex ONLY!!)*
- countersink	
- depth gauge	
- tap	6.5 mm tap
- screw insertion	6.5 mm cancellous screw ***recommend short thread pattern* ***(16 mm)***

* remove temporary fixation before final tightening of the screw

V.D.2.b. 6.5 MM LARGE CANCELLOUS + 4.0 MM "PARTIALLY THREADED" CANCELLOUS (FIG. B)

**** additional point of fixation by inserting a 4.0 mm "partially threaded" cancellous screw into the temporary fixation pin site or other secondary location**

V.D.2.c. 2 X 4.5 MM CANNULATED CANCELLOUS (SELF-TAPPING) (FIG. C)

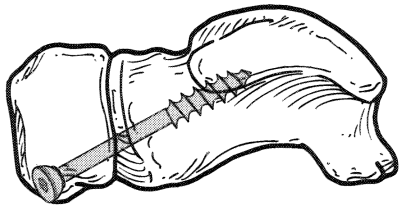
POINTS OF INSTRUCTION:

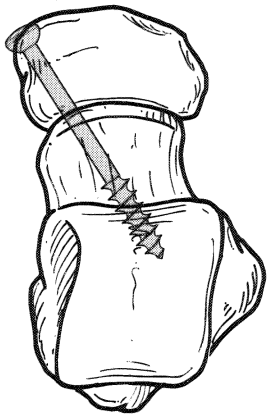
- plantar medial aspect of the navicular up into the neck of the talus
  with second screw from the dorsal aspect of the navicular into the talus

Insertion Sequence - 4.5 mm cannulated cancellous screw "partially threaded"

- guide wire	1.6 mm threaded tip guide wire
- thread drill	3.2 mm cannulated drill
- countersink	*(keep in line with thread hole)*
- measuring device	
- screw insertion	4.5 mm cannulated cancellous screw / **self tapping**

A





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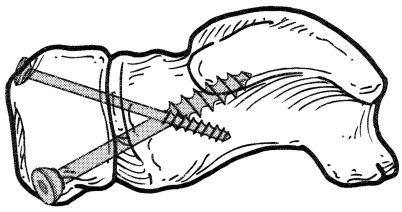

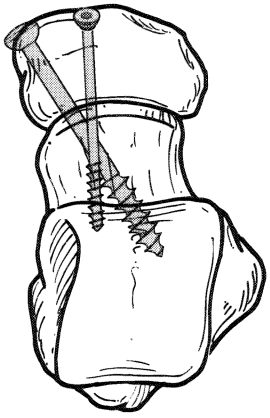

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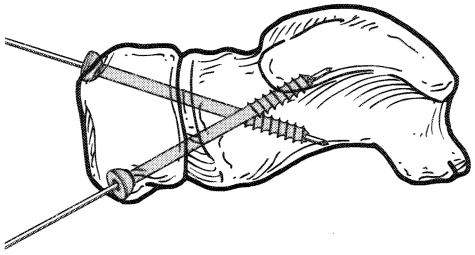
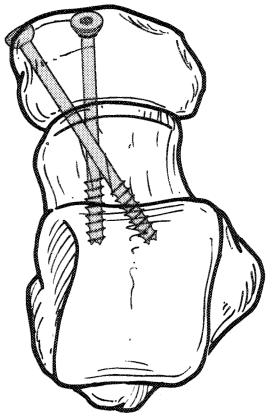




V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.D.3. CALCANEAL - CUBOID JOINT

Technique: *a. 6.5 mm large cancellous*
b. staple fixation

V.D.3.a. 6.5 MM LARGE CANCELLOUS (FIG. A)

POINTS OF INSTRUCTION:

- temporary fixation away from site of insertion

- begin insertion at the dorsal / distal edge of the cuboid
direct drill across the CC joint with a slight medial direction into the body of the calcaneus
(try to avoid penetration through the medial cortex of calcaneus)

Insertion Sequence - 6.5 mm cancellous screw (LFS)

- thread hole	3.2 mm drill bit
- overdrill	4.5 mm drill bit (dorsal cuboid cortex ONLY !!)
- countersink	
- depth gauge	****large "T" handle countersink**
- tap	6.5 mm tap
- screw insertion	6.5 mm cancellous screw
	***may use short thread pattern **(16 mm)** or long thread pattern **(32 mm)** dependent on length of screw past the CC joint and into the calcaneus*

* remove temporary fixation before final tightening of the screw

** alternative orientation for a single 6.5 mm cancellous screw ***(fig. B)***
from the lateral aspect of the neck of the calcaneus, distally into the medial aspect of the cuboid

V.D.3.b. CALCANEAL - CUBOID JOINT / STAPLE FIXATION (FIG. C)

POINTS OF INSTRUCTION:

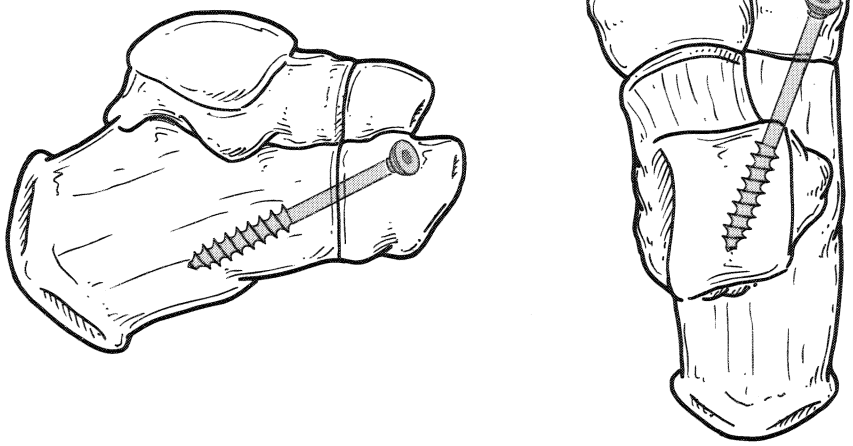
- (2) staple fixation technique

- dorsal and lateral staple placement

- 90° orientation

- **Staple Devices:** Blount staples, 3-M Power "Stapilizer", Uni Clip staples, Nitinol Staples, et.al.,

A



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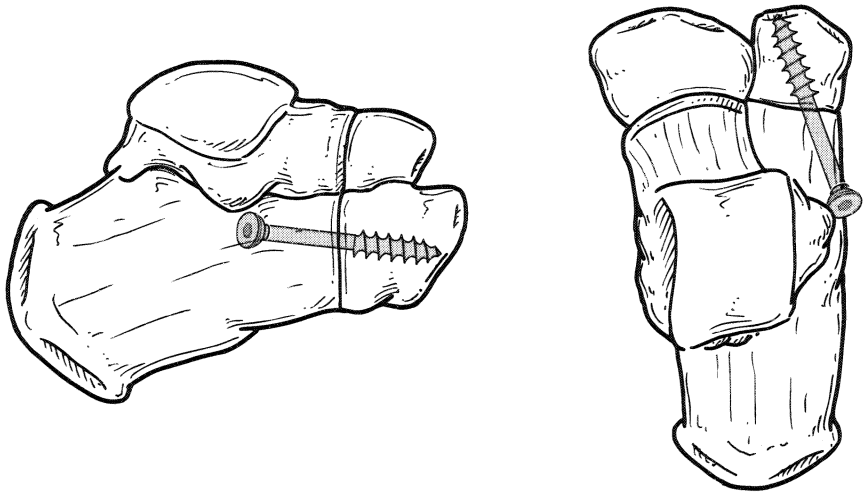

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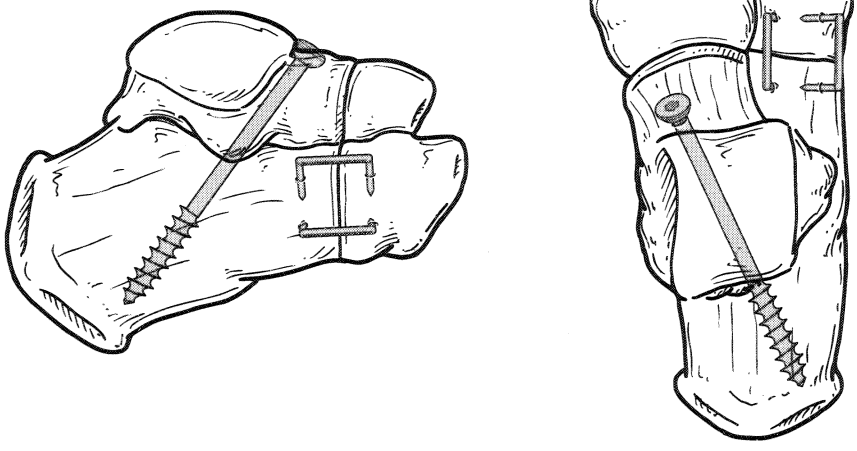


V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.D.4. TRIPLE ARTHRODESIS (FIG. A - D)

PURPOSE:

- (3) x 6.5 mm Large cancellous screw fixation of rearfoot joints for triple arthrodesis

Sequence of Joint Fixaiton

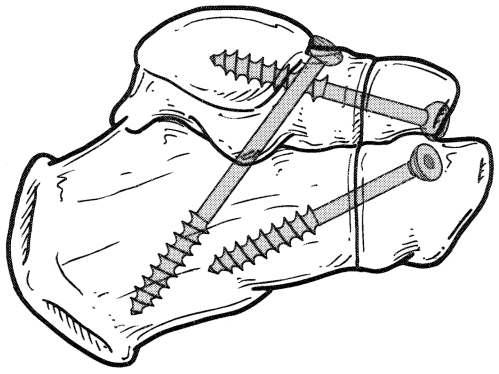
- Temporary (pin) fixation
  align rearfoot joints to desired position and fixate TNJ initially, followed by STJ and then CC

- Permanent Fixation Sequence

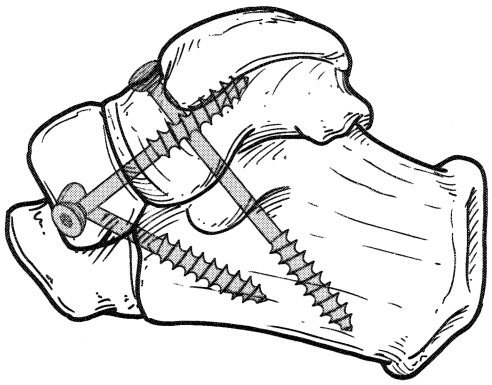
  a. STJ, TNJ, CC

  b. TNJ, STJ, CC *(Vassal alignment of rearfoot joint)*

- resect MTJ then resect STJ
- fuse STJ & then fuse MTJ to align FA to RF



A



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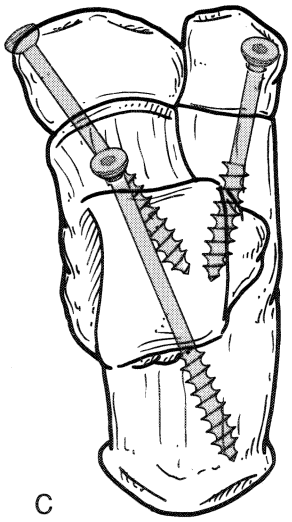

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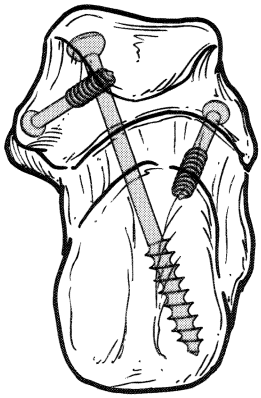


D

- align foot 10-15° externally rotated (abducted)
- moderate amt. of valgus in RF → ↘
  (thall shall NOT varus)

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

ANKLE FUSION

posterior displacement
10° external rotation
slight valgus
neutral flexion
(~~0~~ DF or PF)

V.E.1. "TRIPOD" SCREW TECHNIQUES

V.E.1.a. "TRIPOD" / POSTERIOR - MEDIAL "HOME RUN" SCREW

Technique: *7.3 mm cannulated cancellous screws*
(3) screw configuration
Posterior / Medial **"Home Run" screw*

V.E.1.b. "TRIPOD" / POSTERIOR - LATERAL "HOME RUN" SCREW

Technique: *7.3 mm cannulated cancellous screws*
(3) screw configuration
Posterior / Lateral **"Home Run" screw*

V.E.3. "TUCKER" TECHNIQUE

Technique: *a. Crossed screw fixation / 6.5 mm large cancellous*
b. Fibular buttress / 4.0 mm cancellous screws
c. Anterior "Anti Rock" / Blount staples

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.E.1. "TRIPOD" SCREW TECHNIQUES

V.E.1.a. POSTERIOR - MEDIAL "HOME RUN" SCREW

Technique: *7.3 mm cannulated cancellous screws*
(3) screw configuration
Posterior / Medial ***"Home Run"*** *screw*

POINTS OF INSTRUCTION:

- 2.8 mm guide wires inserted (see directions below) and position confirmed with C-arm

- 7.3 mm cannulated screws inserted in the following sequence using standard technique

Screw #1 is inserted from the posterior medial aspect of the tibia, to the plantar lateral talar neck ***(fig. A, B)***

Screw #2 is from the anterior lateral surface of the distal tibia, to the posterior medial talus ***(fig. C, D)***

Screw #3 is inserted from the medial surface of the distal tibia, to the lateral process of the talus ***(fig. C, D)***

Insertion Sequence - 7.3 mm cannulated cancellous screw

- guide wire 2.8 mm threaded tipped guide wire

- thread hole 5.0 mm drill bit (optional)

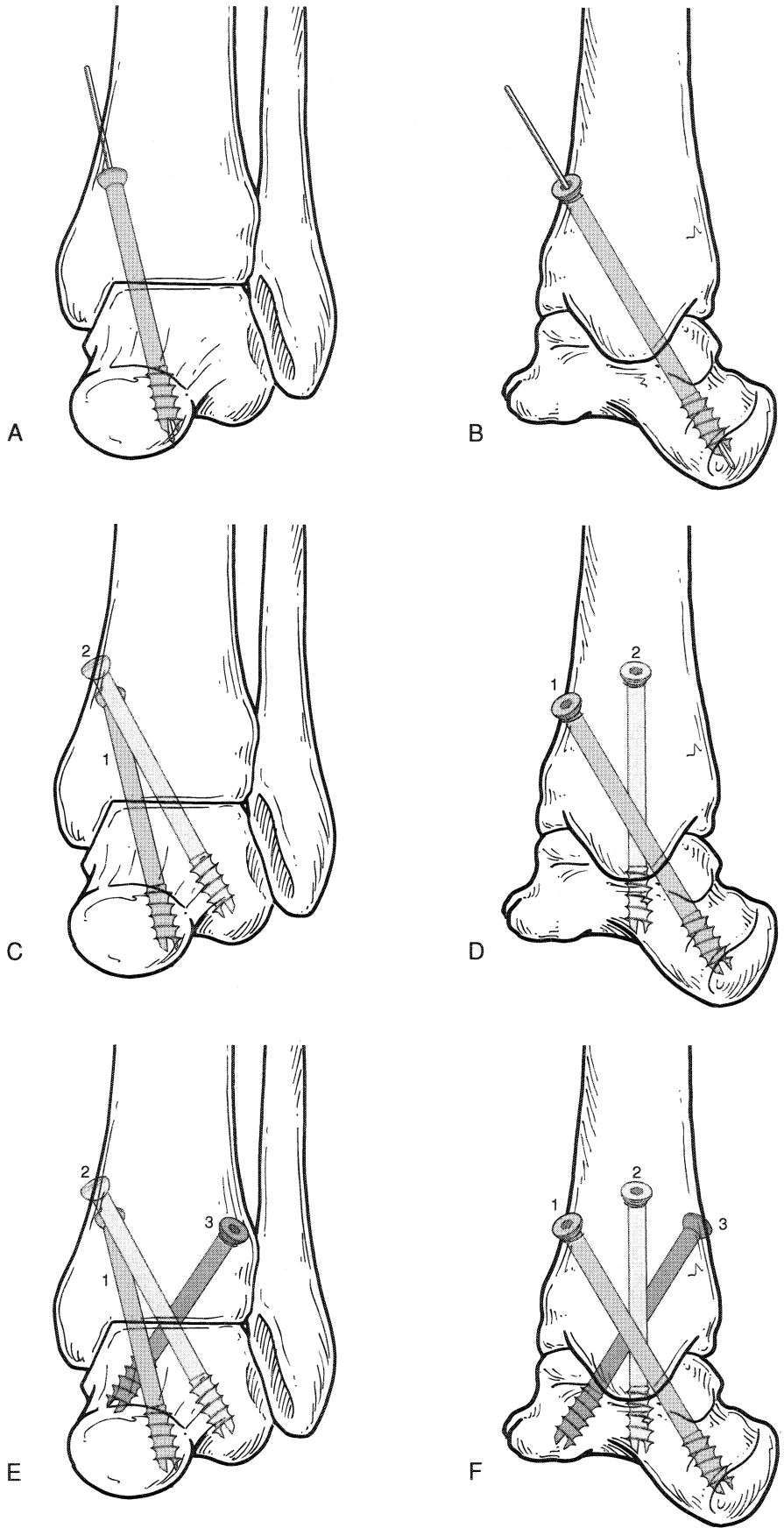
- countersink *(don't be too aggressive!)*

- external measuring device

*** tap** *(optional)* **7.3 mm screw is self-drilling and self-tapping**

- screw insertion 7.3 mm cannulated screw

- remove guide pin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D
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F

V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.E.1. "TRIPOD" SCREW TECHNIQUES

V.E.1.b. POSTERIOR - LATERAL "HOME RUN" SCREW

Technique: *7.3 mm cannulated cancellous screws*
(3) screw configuration
Posterior / Lateral ***"Home Run"*** *screw*

Points of Instruction:

- 2.8 mm guide wires inserted (see directions below) and position confirmed with C-arm

- 7.3 mm cannulated screws inserted in the following sequence using standard technique

Screw #1 is inserted from the posterior lateral aspect of the tibia, to the plantar medial talar neck ***(fig. A, B)***

Screw #2 is inserted from the medial surface of the distal tibia, to the lateral process of the talus ***(fig. C, D)***

Screw #3 is from the anterior lateral surface of the distal tibia, to the posterior medial talus ***(fig. C, D)***

Insertion Sequence - 7.3 mm cannulated cancellous screw

- guide wire 2.8 mm threaded tipped guide wire

- thread hole 5.0 mm drill bit **recommended in dense tibial cortex

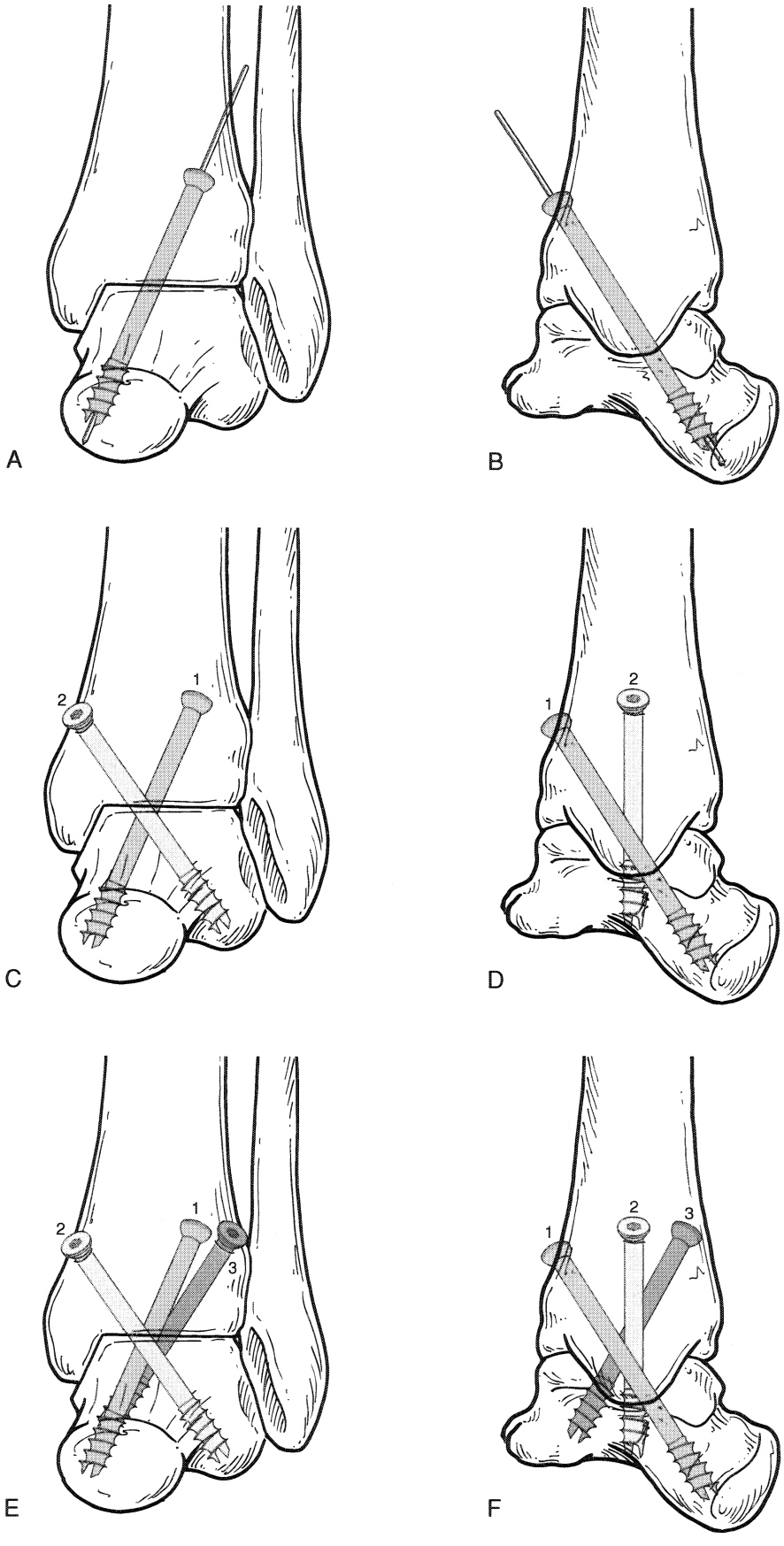
- countersink

- external measuring device

*** tap** *(optional)* **7.3 mm screw is self-drilling and self-tapping**

- screw insertion 7.3 mm cannulated screw

- remove guide pin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V. FOOT AND ANKLE ARTHRODESIS *(screw fixation techniques)*

V.E.3. ANKLE FUSION / "TUCKER" TECHNIQUE

Technique: *a.* ***Crossed screw fixation*** / *6.5 mm large cancellous screws*
b. ***Fibular buttress*** / *4.0 mm cancellous screws*
c. ***Anterior "Anti Rock"*** / *Blount staples*

PURPOSE:
- technique of ankle joint fusion with a combination of different internal fixation principles
- combination of different implants including staples, small and large cancellous screws

POINTS OF INSTRUCTION:
- fibular "take-down" (optional)

Temporary Fixation - 5/64 in. Steinmann pins inserted in the intended location for the two crossing 6.5 mm cancellous screws

Crossing Screw Technique - 6.5 mm Large cancellous screws ***(fig. A)***
- 1st screw / anterior medial aspect of the tibia toward the lateral aspect of the body of the talus
- 2nd screw / anterior lateral aspect of the distal tibial toward the posterior / medial aspect of the body of the talus

Insertion Sequence - 6.5 mm Large cancellous screws

- thread hole	3.2 mm drill bit
- overdrill	4.5 mm drill bit **tibial cortex ONLY!!**
- countersink	
- depth gauge	
- tap	6.5 mm tap
- screw insertion	6.5 mm cancellous screw

** recommend "short thread pattern" (16 mm) for purchase of talus*

* remove temporary fixation before final tightening of the screw

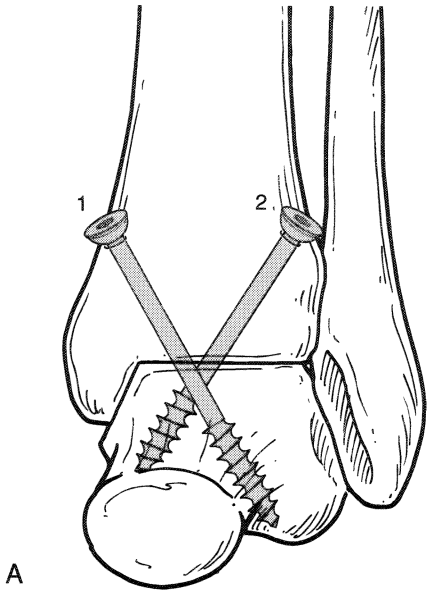
Fibular Buttress - Fixation of Syndesmosis and lateral talofibular articulation ***(fig. B)***
(can be done with intact or osteotomized fibula, after resection of syndesmosis and lateral talofibular joint)

- lateral fibula, above the joint into tibia (4.0 mm "partially threaded" cancellous screw / 1 or 2 screws)

- lateral distal fibula into the talus (4.0 mm "partially threaded" cancellous screw)

Adjunct Fixation ***(fig. C)***

* anterior Blount staples **"anti-rocking"** device



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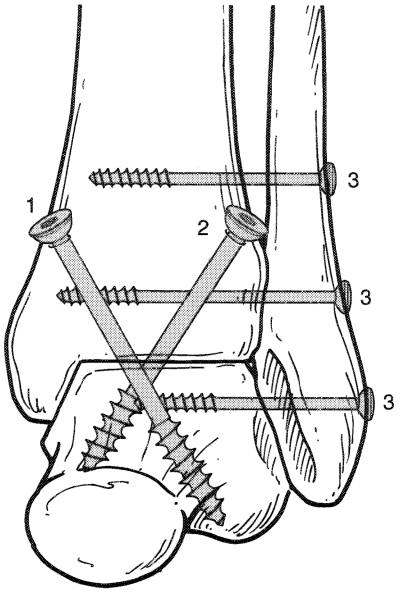

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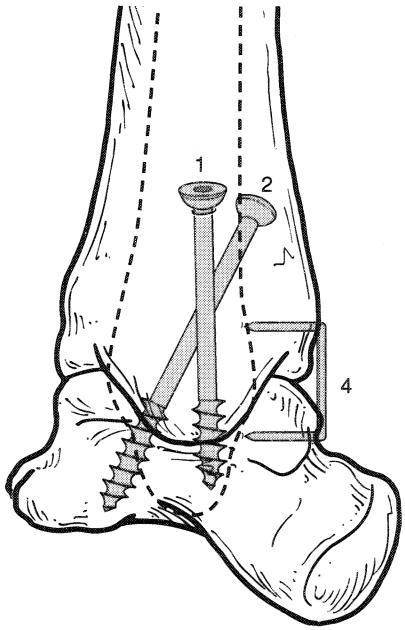


C

VI. PLATE FIXATION

PRINCIPLES OF PLATE FIXATION

VI.A. AXIAL COMPRESSION PLATE PRINCIPLES

Technique: *- "pre-bending"*
- load screw principle

VI.B. LESSER METATARSAL FRACTURE

Technique: *- axial plate compression / "pre-bending" / load screw technique*
- 1/4 tubular plate / 2.7 mm cortical screws

VI.C. 1ST MPJ FUSION

Technique: *- combination; interfragmental compression / axial plate compression*
- 4.0 mm cancellous screw / 1/3 tubular plate / 3.5 mm cortical screws

VI.D. 1ST MPJ FUSION WITH INTERPOSITIONAL BONE GRAFT

Technique: *- axial compression, "load screw" technique*
- 2.7 mm LC-DCP (6-hole) / 2.7 mm cortical screws

VI. PLATE FIXATION

Principles of Plate Fixation

Plate fixation utilized a variety of different mechanical principles for creation of a stable osteosynthesis. These principles include:

- Neutralization
- Axial Compression
- Buttressing
- Anti-glide (capture of oblique fragment)
- Combination fixation

Neutralization (***fig. A*** **- SER fracture)**

Technique: *- interfragmental compression screw*
- neutralization plate

Axial Compression (***fig. B*** **- Lesser metatarsal fracture)**

Technique: *- "pre-bending"*
- load screw principle

Buttress (***fig. C*** **- fibular defect / repair with bone graft)**

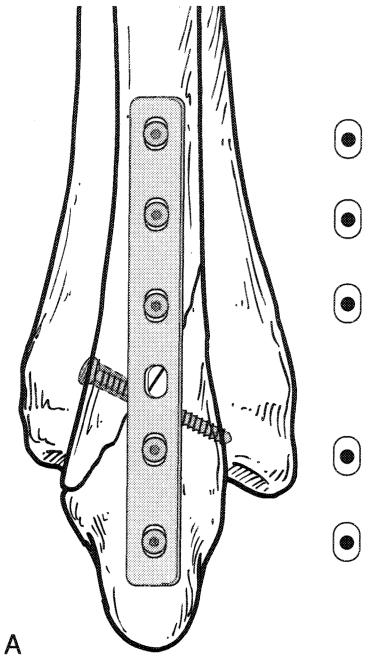
Technique: *- maintenance of length and alignment of severely comminuted fractures or bone segment loss or deficit*

Anti-glide (***fig. D*** **- SER fracture)**

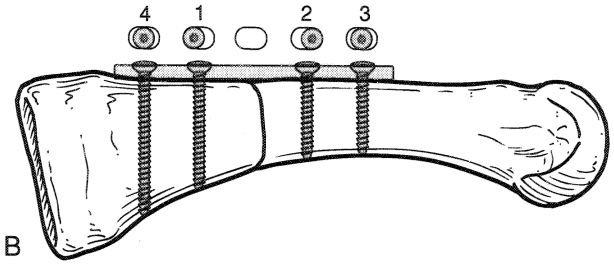
Technique: *- specialized technique of buttressing, employing maintenance of length by use of a "trick" screw and posterior plate application to "capture" the acute angle of the fracture*

Combination (***fig. E*** **- 1st MPJ arthrodesis)**

Technique: *- combination of interfragmental compression by single screws axial compression plating techniques*



A



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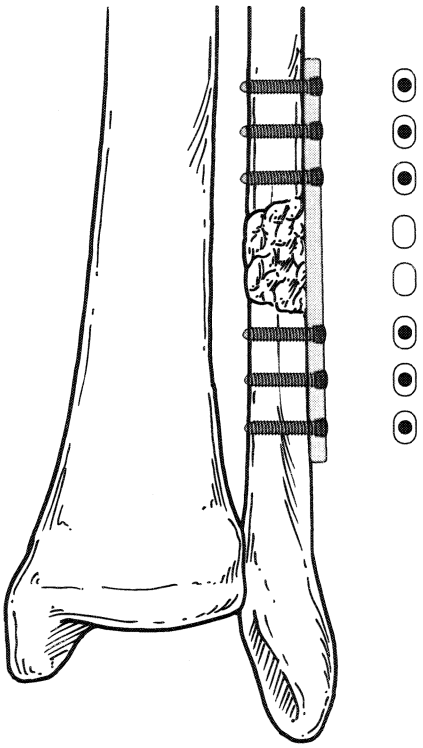

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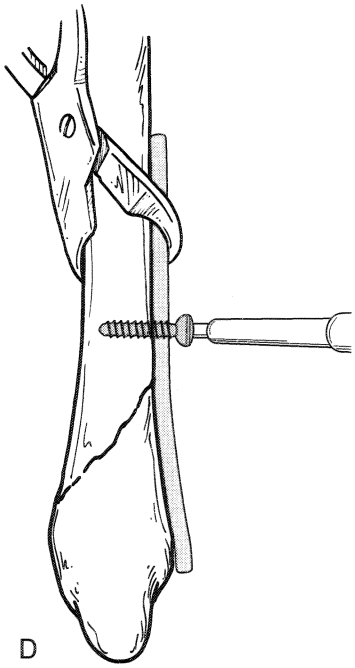

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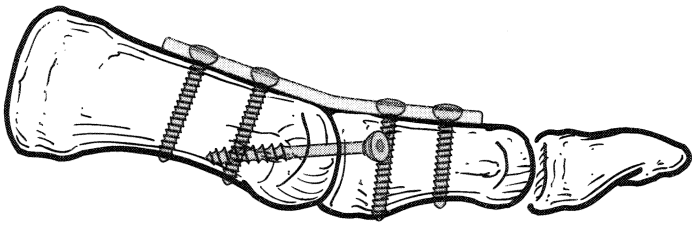


E

VI. PLATE FIXATION

VI.A. AXIAL COMPRESSION PLATE PRINCIPLES

Technique: *- "pre-bending"*
- load screw principle

PURPOSE:

- orientation: long bone with transverse fracture or arthrodesis technique
- purpose and effect of "pre-bending"
- technique of axial compression utilizing the "load screw" technique

POINTS OF INSTRUCTION:

- axial compression **without** "pre-bending" of the plate will cause gapping of the opposite cortex
- tightening of the "load screws" creates compression at the near cortex... *(under the plate)*
  and causes gapping of the far cortex **(eccentric load of tubular bone!!!)** ***(fig. A)***

- **To prevent gapping of the far cortex, you must "PRE-BEND" the plate** ***(fig. B)***

- pre-bend the plate with the center of the plate lifted off of the bone approximately 5 mm
  with contact of the plate with the bone at the ends of the plate

- then proceed with insertion of the "load screws"

- "load screws" are placed in the holes of the plate closest to the fracture
  the "load screws" are inserted by drilling in an "off-set" position within the hole of the plate
  (offset away from the fracture)
  this causes the screw and bone to shift toward the fracture line
  when the screw is tightened and the head of the screw seats itself in the hole of the plate

- as the "load screws" shift toward the center of the hole in the plate,
  the far cortex comes in contact initially,
  as the screws tighten, pressure is spread out evenly across the fracture surface
  and straightens out the plate

- the "pre-bent" plate acts as a leaf spring and keeps the opposite cortices apposed.

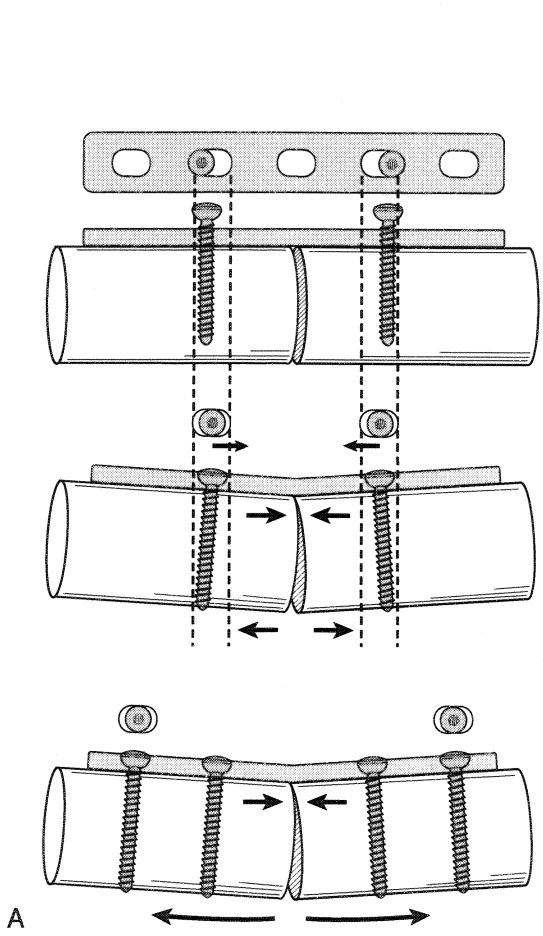
Insertion Sequence - 3.5 mm cortical screw (plate)

- thread hole 2.5 mm drill bit
(off-set drill guide, away from fracture for "load screws")

- depth gauge

- tap 3.5 mm cortical tap

- screw insertion 3.5 mm cortical screw



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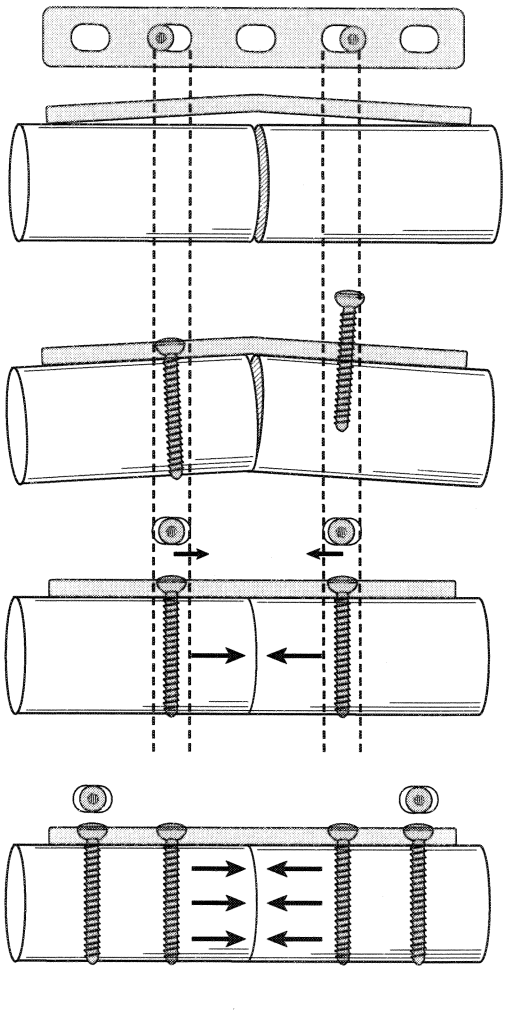


B

VI. PLATE FIXATION

VI.B. LESSER METATARSAL FRACTURE

Technique: ***- axial plate compression*** */ "pre-bending" / load screw technique*
- 1/4 tubular plate / 2.7 mm cortical screws

PURPOSE:

- technique of axial compression using a small 1/4 tubular plate and 2.7 mm cortical screws
- long bone with transverse fracture orientation ***(fig. A)***
- pre-bending, load screw compression

POINTS OF INSTRUCTION:

- selection of 4-5 hole plate

- pre-bend the plate with the center of the plate lifted off of the bone approximately 5 mm ***(fig. B)***

- align the plate to evenly span the transverse metatarsal fracture ***(fig. C)***

- temporary attachment of the plate to the bone segments with bone clamps

- execute "load screw" insertion by off-set drilling holes on either side of the fracture ***(fig. D)***

- tighten load screws to create axial compression of the fracture
** dorsal view shows final tightening of "load screws" and compression effect*

- insert remaining screws in a centralized or neutral position ***(fig. D)***

Insertion Sequence - 2.7 mm cortical screw / plate fixation

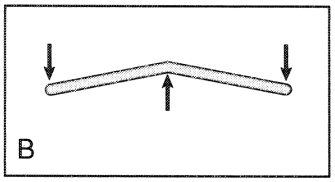
- thread hole 2.0 mm drill
(off-set drill guide, away from fracture for "load screws")
(centralizing drill guide for remainder of screws)

- depth gauge

- tap 2.7 mm cortical tap

- screw insertion 2.7 mm cortical screw

A



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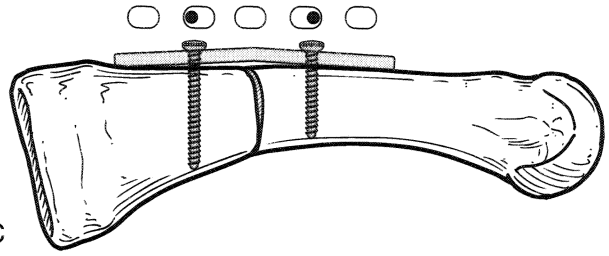

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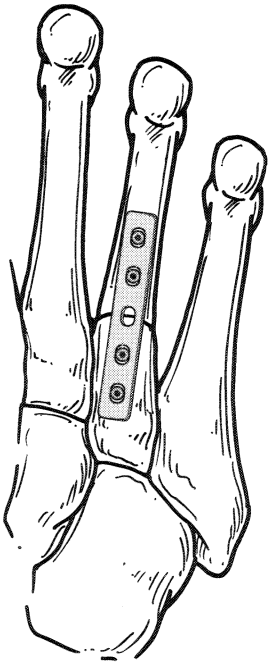

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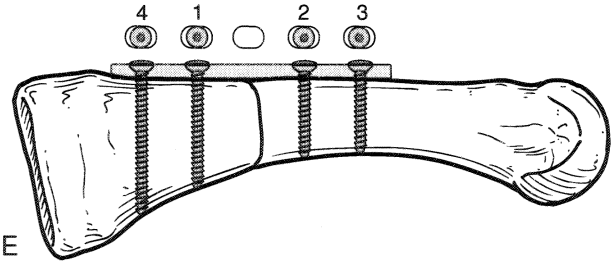


E

VI. PLATE FIXATION

VI.C. 1ST MPJ FUSION

Technique: ***- combination;*** *interfragmental screw compression / axial compression plate*
- 4.0 mm cancellous screw / 1/3 tubular plate / 3.5 mm cortical screws

PURPOSE:

- interfragmental compression initially created with a single 4.0 mm "partially threaded" cancellous screw
- axial compression created with a 1/3 tubular plate and "load screws" *(3.5 mm cortical screws)*

* *axial compression and interfragmental compression can be used at the same time because of the transverse orientation of the arthrodesis in a long bone system*

POINTS OF INSTRUCTION:

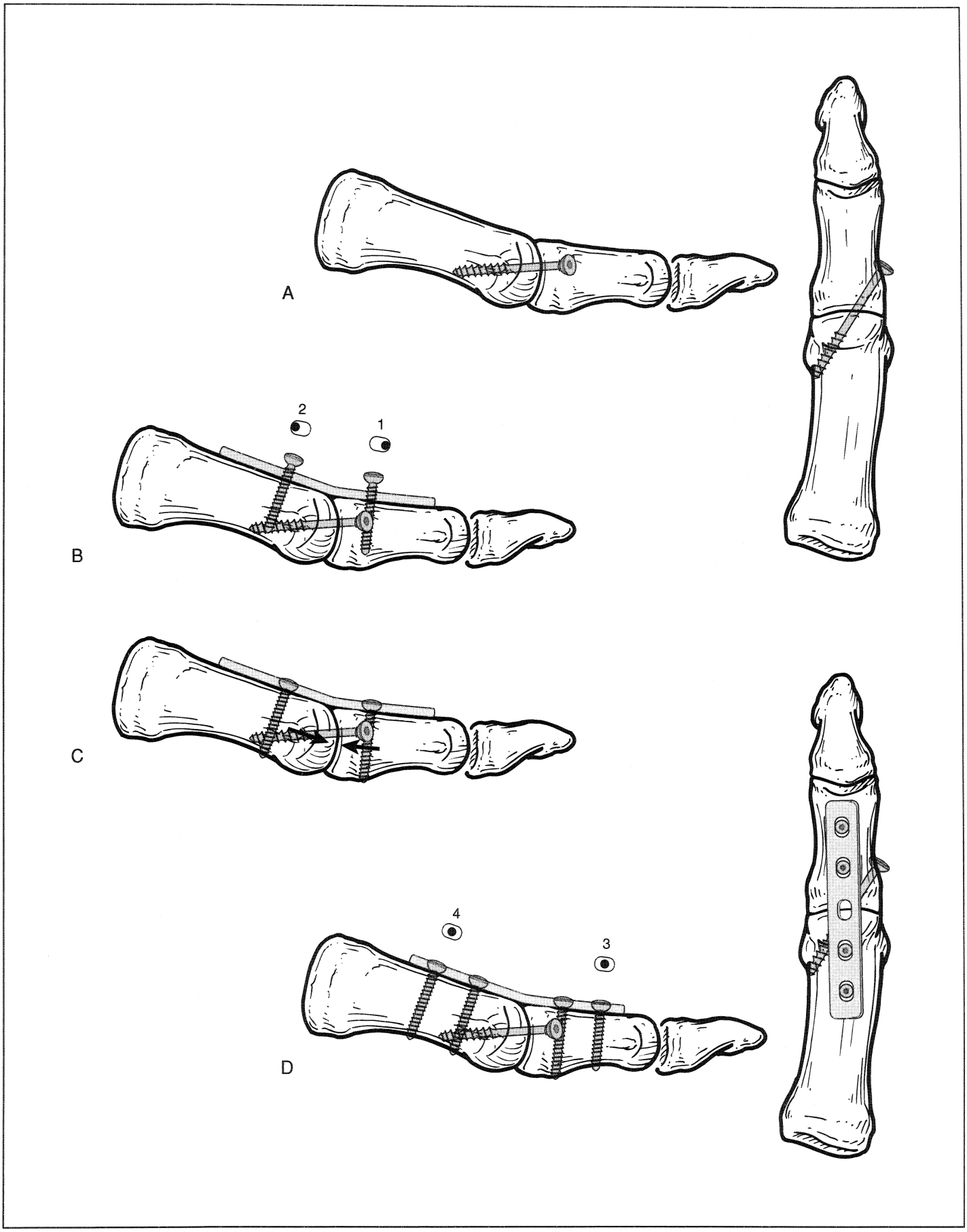
- temporary fixation / 1.6 mm K-wire
- insertion of 4.0 mm cancellous screw from medial aspect of the base of the proximal phalanx ***(fig. A)*** across the MPJ
- removal of temporary fixation
- application of 5-hole, 1/3 tubular plate on the dorsal aspect of MPJ
- proximal aspect of the plate is secured to the metatarsal with centralized drill holes
- 1 OR 2 "load screws" are inserted with "off-set" drill technique ***(fig. B, C)***
- remaining screws are inserted, centered in the open holes of the plate ***(fig. D)***
- re-tighten all screws

Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- pre-drill	1.6 mm K-wire
- thread hole	2.5 mm drill
- countersink	*(keep in line with thread hole)*
- depth gauge	
- tap	4.0 mm cancellous tap *(1.75 mm pitch)*
- screw insertion	4.0 mm "partially threaded" cancellous screw *(threads must cross the arthrodesis site)*

Insertion Sequence - 3.5 mm cortical screw / plate fixation

- thread hole	2.5 mm drill *("load screw" is inserted, off-set away from the arthrodesis site)* *(neutral screws are inserted in the center of the remaining holes)*
- depth gauge	
- tap	3.5 mm cortical tap *(1.25 mm pitch)*
- screw insertion	3.5 mm cortical screw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VI. PLATE FIXATION

VI.D. 1ST MPJ FUSION WITH INTERPOSITIONAL BONE GRAFT

Technique: *- **axial compression,** "load screw" technique*
*- 2.7 mm **LC-DCP** (6-hole) / 2.7 mm cortical screws*

PURPOSE:

- axial compression with interpositional bone graft
- demonstrating ability of the "DCP" plate to create axial compression with (4) screws

POINTS OF INSTRUCTION:

- fashion and insert interpositional bone graft

- dorsal application of 6-hole, LC-DCP plate *(2.7 mm)*

- initially fixate the plate to bone graft with a single 2.7 mm cortical screw ***(fig. A)***

- insert "load screws" in the 1st holes, proximal and distal to the bone graft ***(fig. B, C)***

- 3rd and 4th screws can be used for additional compression... ***(fig. D)***
  BUT, must 1st loosen screws 1 and 2 before tightening 3 and 4 into the holds of the plate
  THEN, retighten screws 1 and 2

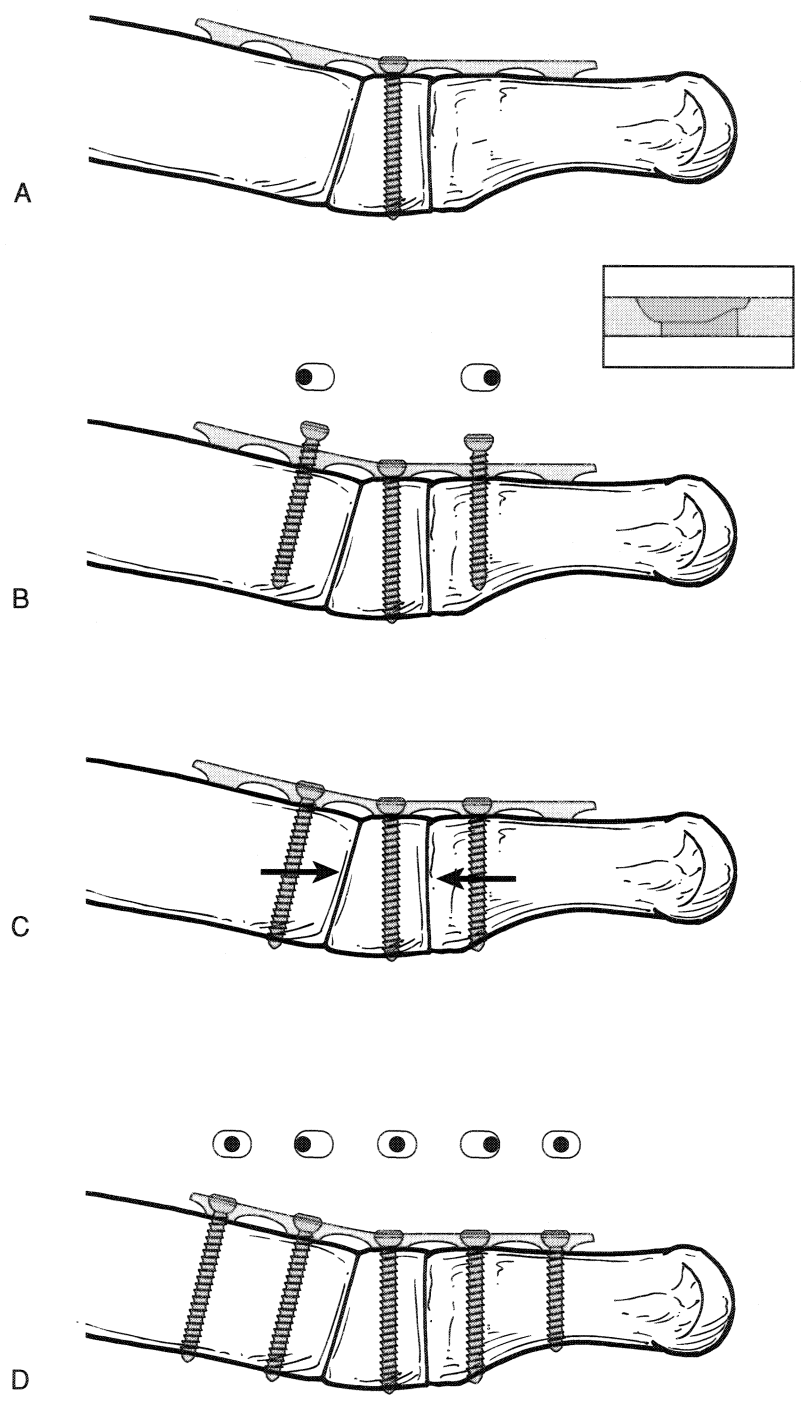
Insertion Sequence - 2.7 mm cortical screw / plate fixation

- thread hole 2.0 mm drill
(off-set drill guide, away from fracture for "load screws")
(centralizing drill guide for remainder of screws)

- depth gauge

- tap 2.7 mm cortical tap

- screw insertion 2.7 mm cortical screw


A
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VI. PLATE FIXATION

VI.E. LAPIDUS (PLATE TECHNIQUE)

Technique: *- **combination;** interfragmental compression / axial plate compression*
- 4.0 mm cancellous + 1/3 tubular plate

VI.F. LAPIDUS (LOCKING "T" PLATE TECHNIQUE)

Technique: *- **combination;** interfragmental compression / "locking" plate*
- 4.0 mm cancellous screw / Locking "T" plate

VI.G. MEDIAL COLUMN FUSION (CHARCOT)

Technique: *- **combination;** interfragmental compression / "locking" plate*
- 4.0 mm cancellous screw / 1/3 tubular "locking plate"

VI.H. NC ARTHRODESIS

Technique: *- "H" plate (5-hole, non-locking)*
- "offset" load screw principle (x 4)
- 4.0 mm fully threaded cancellous screws

VI. PLATE FIXATION

VI.E. LAPIDUS (PLATE TECHNIQUE)

Technique: ***- combination;*** *interfragmental compression / axial compression plate*
- 4.0 mm cancellous / 1/3 tubular plate, 3.5 mm cortical screws

PURPOSE:

- combined techniques of compression fixation using a single 4.0 mm cancellous screw and a 1/3 tubular plate with axial compression
* axial compression and interfragmental compression can be used at the same time because of the transverse orientation of the arthrodesis in a long bone system

POINTS OF INSTRUCTION:

- temporary fixation with a dorsal 1.6 mm K-wire

✱ insertion of 4.0 mm "partially threaded" cancellous screw ***(fig. A)***
from the plantar medial aspect of the metatarsal base
up into the proximal, superior and lateral aspect of the cuneiform

Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- thread hole	2.5 mm drill (centralizing drill guide)
- depth gauge	
- tap	4.0 mm cancellous tap *(1.75 mm pitch)*
- screw insertion	4.0 mm "partially threaded" cancellous screw

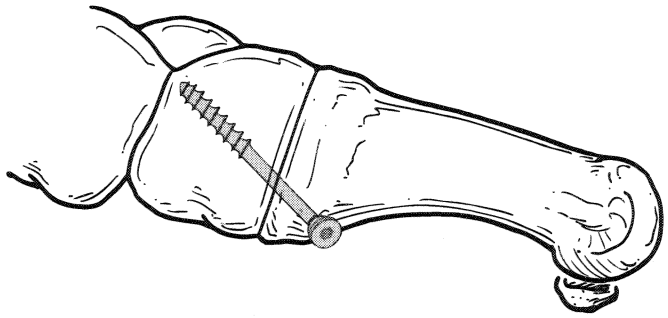
Axial Compression Plate

- select a 5-hole, 1/3 tubular plate for medial application
- pre-bend the plate
- secure the plate to the cuneiform with (2) **4.0 mm "fully threaded" cancellous screws** ***(fig. B)***
- "off-set" drill and insert a 3.5 mm cortical screw in 1st hole distal to MCJ ***(fig. C)***
- the metatarsal screws should purchase both cortices ***(fig. E)***
- remove temporary fixation device
- final tightening of load screw and proximal screws
- insertion of the remainder of plate screws with neutral 3.5 mm cortical screws ***(fig. D)***

* *potential for additional compression screw from the dorsal aspect of the metatarsal base (in the site of the temporary fixation pin)*

** *There is potential to create the "load screw" effect, proximal and distal to the arthrodesis by loosening the proximal screws initially, then sliding the plate distally, so that the proximal screws are now both off-set in the holes of the plate. Insert the first screw in the metatarsal base in an "off-set" alignment. This maneuver will create the effect of "load screws" on the proximal and distal sides of the arthrodesis.*

A



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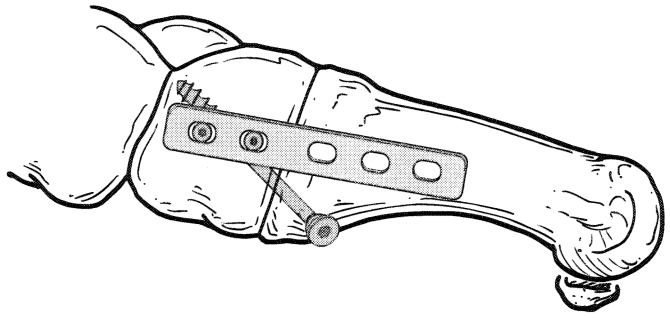

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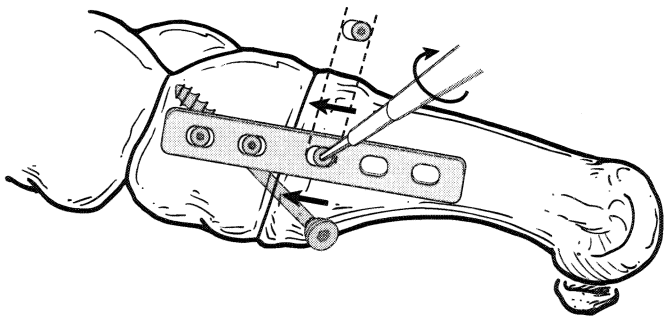

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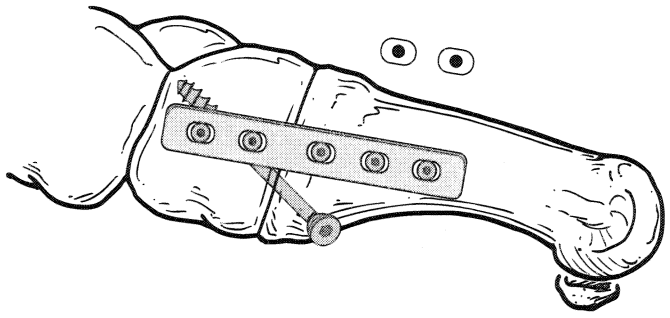

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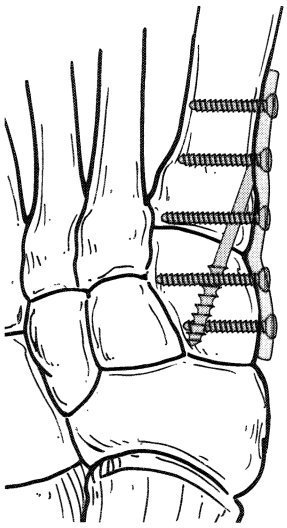


VI. PLATE FIXATION

VI.F LAPIDUS (LOCKING "T" PLATE TECHNIQUE)

Technique: - ***combination;*** *interfragmental compression / "locking" plate*
- *4.0 mm cancellous screw / Locking "T" plate*

PURPOSE:
- use of a specialized locking plate

POINTS OF INSTRUCTION:

Interfragmental Compression Screw ***(fig. A, C)***
- interfragmental compression, 4.0 mm "partially threaded" cancellous screw is inserted dorsally

Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- pre-drill	1.6 mm K-wire
- thread hole	2.5 mm drill
- countersink	*(keep in line with thread hole)*
- depth gauge	
- tap	4.0 mm cancellous tap *(1.75 mm pitch)*
- screw insertion	4.0 mm "partially threaded" cancellous screw

"Locking" "T" Plate Sequence ***(fig. A - C)***
- Locking "T" plate is contoured to approximate the medial contour of the metatarsal cuneiform surfaces

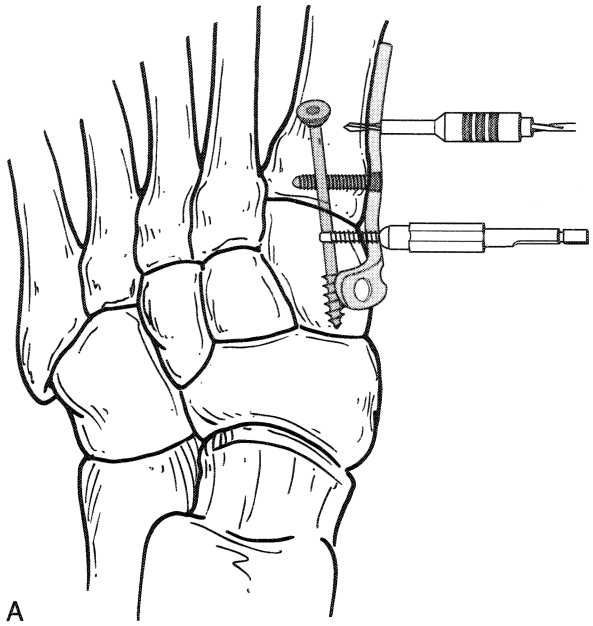
- the plate may be initially applied to the bone surface with a "whirly bird" device (or simply attach the plate with a standard "round headed" screw or a "threaded" locking screw

- it is possible to apply this plate and create axial compression if a standard "round headed" screw is used as a "load screw"

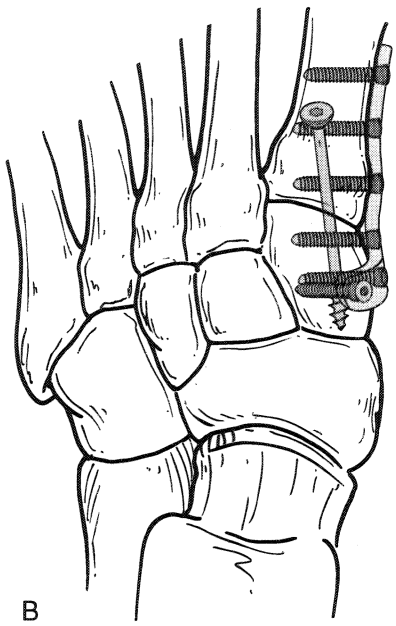
- if only threaded "locking screws" are used, the plate performs as a neutralization plate but gives the additional stability of the "locking plate" system

Insertion Sequence - 3.5 mm "locking" screws

- threaded drill guide	(inserted initially into each hole for insertion of each "locking" screw)
- thread hole	2.8 mm drill (1 or 2 cortices)
- remove drill guide	
- depth gauge	
- screw insertion	3.5 mm "locking" screw / "star drive" screw driver or power "torque device" followed by final hand tightening



A



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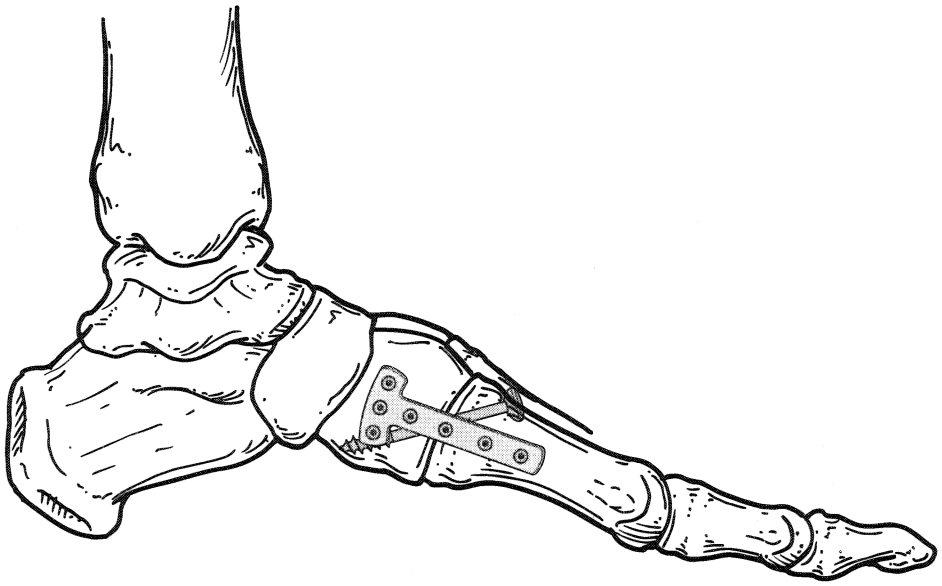


C

VI. PLATE FIXATION

VI.G. MEDIAL COLUMN FUSION (CHARCOT)

Technique: - ***combination;*** *interfragmental screw compression / "locking" plate*
- 4.0 mm cancellous screw / 1/3 tubular "locking" plate

PURPOSE:

- multiple joint fusions of the medial column
- principles and technique of fixation using the "locking" plate system and technology
- plate functions as a neutralization plate

POINTS OF INSTRUCTION:

- primary compression with 4.0 mm "partially threaded" cancellous screws MC, CN joints ***(fig. A)***

- medial application of 1/3 tubular "locking" plate with bone clamp or "whirly bird" device ***(fig. B)***

- insertion of 3.5 mm "locking" screws ***(fig. C)***

Insertion Sequence - 3.5 mm "locking" screws

- threaded drill guide (inserted initially into each hole for insertion of each "locking" screw)

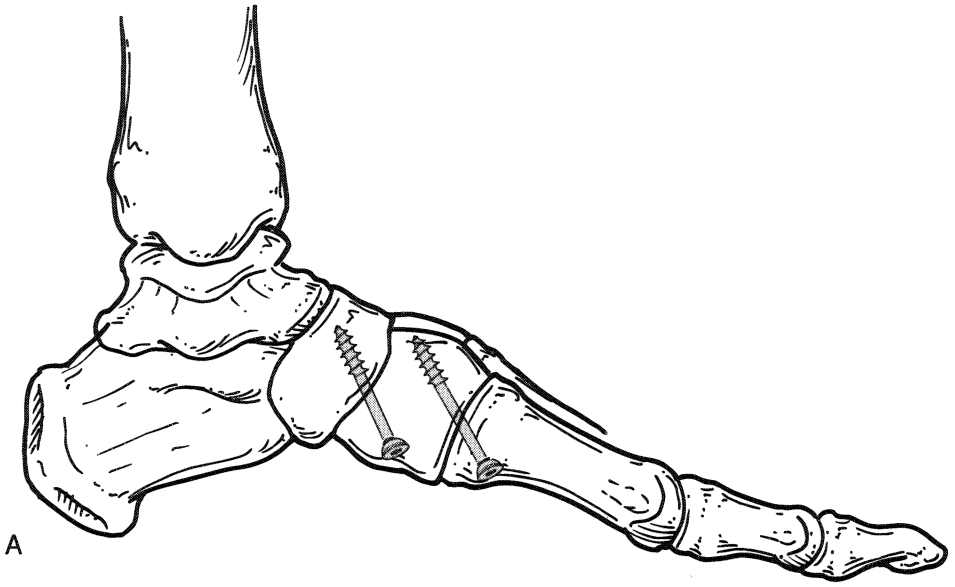
** *it is critical to use the threaded drill guide when drilling for insertion of the locking screws, "free hand" or uncontrolled use of the drill will potentially damage the thread pattern in the plate or "mis-align" the screw threads to the threads of the plate preventing accurate engagement and locking of the screw to the plate*

- thread hole 2.8 mm drill *(1 or 2 cortices)*

- remove drill guide

- depth gauge

- screw insertion 3.5 mm "locking" screw / "star drive" screw driver
or power "torque device" followed by final hand tightening



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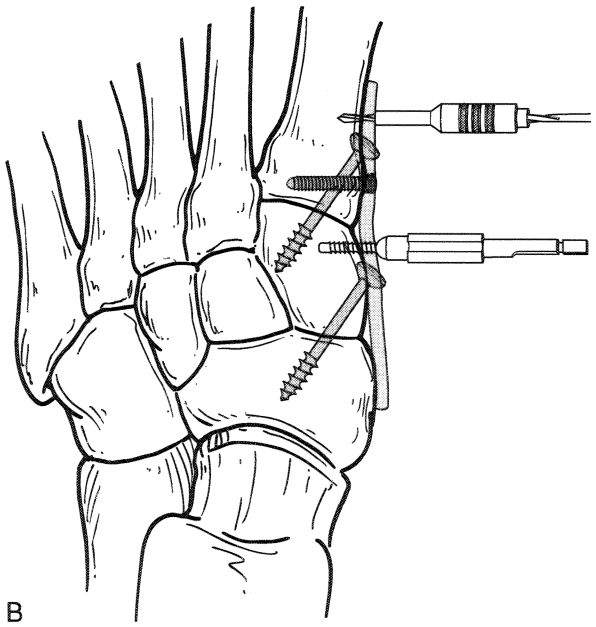

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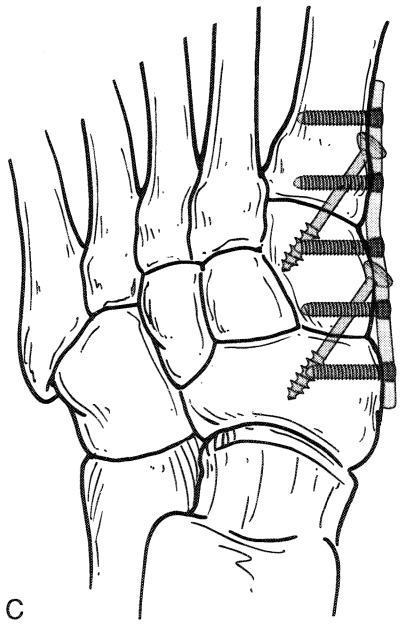


C

VI. PLATE FIXATION

VI.H. NC ARTHRODESIS

Technique: *- **"H" plate** (4.0 mm "fully threaded" cancellous screws, 5-hole, non-locking)*
- "offset" load screw principle (4) "fully threaded" cancellous screws

PURPOSE:

- use of a specialized "H" plate for fixation of the navicular cuneiform arthrodesis

POINTS OF INSTRUCTION: ***(fig. A, B)***

- the plate is positioned so that the central hole is directly over the fusion mass
- the first screw is inserted in the navicular, across the entire transverse expanse of the navicular in the superior 1/2 of the bone
- the initial fully threaded, 4.0 mm cancellous screw is delivered to the edge of the plate but not tightened
- the plate is shifted distally to create an "off-set" position of the 1st screw
- the second screw is placed in the distal superior plate hole, against the distal edge of the plate hole
- the proximal inferior hole is then filled with the screw at the proximal edge of the plate hole
- and finally, the distal inferior hole is filled in a screw inserted at the distal edge of the plate hole
- tightening of all four "off-set" screws will create axial compression of the navicular cuneiform complex

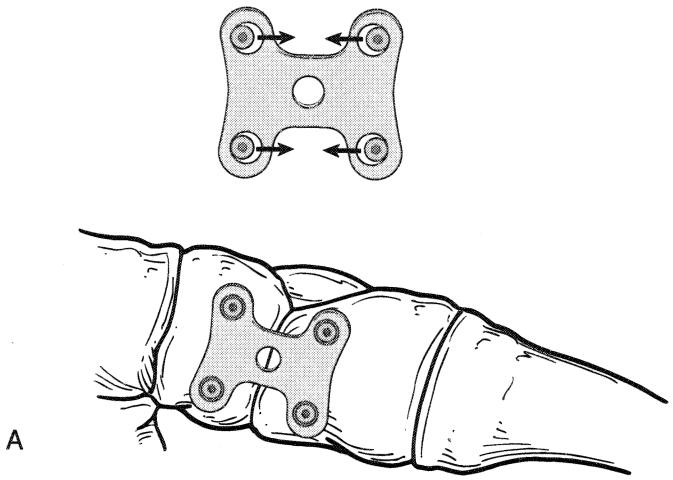
Insertion Sequence - 4.0 mm "fully threaded" cancellous screw (SFS)

- thread hole 2.5 mm drill

- depth gauge

- tap 4.0 mm cancellous tap (1.75 mm pitch)

- screw insertion 4.0 mm "fully threaded" cancellous screw



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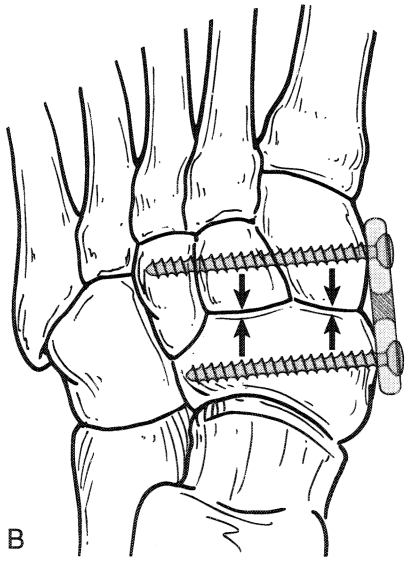


B

VII. MALLEOLAR FRACTURES

FIBULAR MALLEOLUS:

VII.A.1. **WEBER A** - ***Technique:*** *K-wire splintage / tension band wire / "single twist" technique*

VII.A.2. **WEBER B** - ***Technique:*** *"anchor / compression" / (3) x 3.5 mm cortical screw (*long oblique)*

VII.A.3. **WEBER B** - ***Technique:*** *3.5 mm interfragmental screw + "neutralization" plate*

VII.A.4. **WEBER B** - ***Technique:*** *"Anti-glide" plate*

VII.A.5. **WEBER C** - ***Technique:*** *interfragmental compression screw / neutralization plate / syndesmotic screw*

MEDIAL MALLEOLUS:

VII.B.1. **MEDIAL AVULSION** - ***Technique:*** *K-wire splintage / tension band wire / "double twist"*

VII.B.2. **MEDIAL AVULSION** - ***Technique:*** *(2) x 4.0 mm "partially threaded" cancellous screws*

VII.B.3. **MEDIAL SHEAR** - ***Technique:*** *"Schuberth" Anti-glide plate + (2) x 4.0 mm canc. screws*

POSTERIOR MALLEOLUS

VII.C.1. **POSTERIOR MALLEOLUS - "Direct"** - ***Technique:*** *4.0 mm cancellous screw*

VII.C.2. **POSTERIOR MALLEOLUS - "Indirect"** - ***Technique:*** *4.0 mm cancellous screw*

VII. MALLEOLAR FRACTURES

FIBULAR MALLEOLUS:

VII.A.1. WEBER A (TRANSVERSE / AVULSION)

Technique: *K-wire splintage / tension band wire / "single twist" technique*

VII.A.2. WEBER B (LONG - OBLIQUE SER)

Technique: *"anchor / compression" / (3) x 3.5 mm cortical screws*

VII.A.3. WEBER B (SHORT - OBLIQUE SER)

Technique: *3.5 mm interfragmental compressions screw + "neutralization" plate*

VII.A.4. WEBER B (SHORT - OBLIQUE SER)

Technique: *"Anti-glide" plate*

VII.A.5. WEBER C (HIGH FIBULAR FRACTURE / COMMINUTED, BUTTERFLY FRAGMENT)

Technique: *Interfragmental compressions screws / neutralization plate / syndesmotic screw*
Locking 1/3 tubular plate

VII. MALLEOLAR FRACTURES

FIBULAR MALLEOLUS

VII.A.1. WEBER A (TRANSVERSE / AVULSION)

Technique: *K-wire splintage / tension band wire / "single twist" technique*

PURPOSE:

- K-wire splintage and tension band wire technique for fixation of avulsion fractures

POINTS OF INSTRUCTION:

- reduce the fracture with double sharp bone clamp

- parallel pin fixation with 1.6 mm K-wires
- use of parallel drill guide *(optional)*

- **orientation of pins** is parallel with the lateral cortex of the fibula ***(fig. A)***
- **perpendicular to the fracture line**

* *penetrate the medial cortex of the fibula above the fracture, back up to accommodate bend and push in*

- drill hole from posterior to anterior above the fracture line, "equidistant" from insertion of pins ***(fig. A)***

Wire Pass Technique / "Single Twist" ***(fig. B - E)***

- pass 22 ga. monofilament wire through drill hole
- loop around pins in a figure "8" pattern

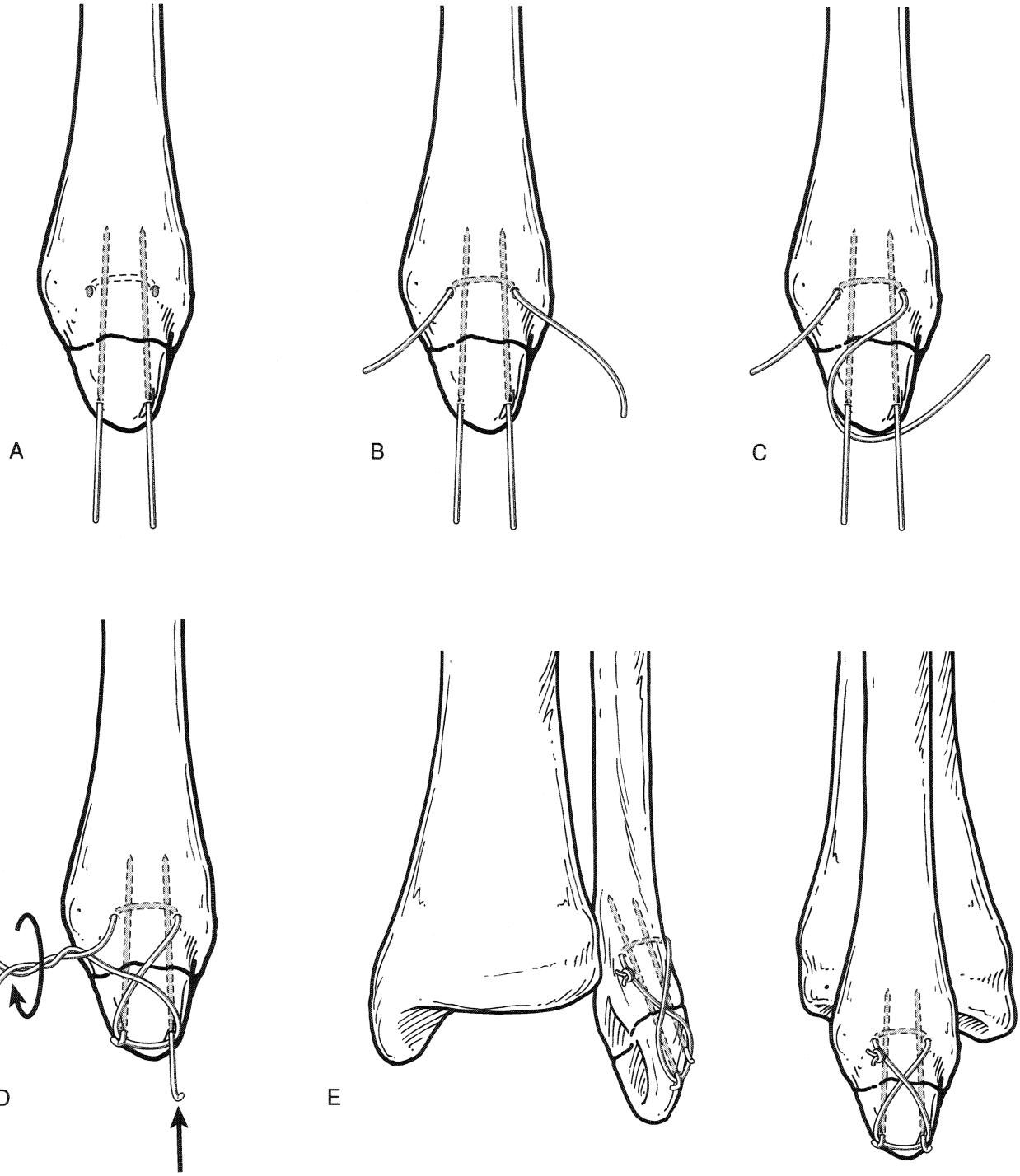
- tighten with a single twist technique

** *double twist technique can be used (see medial malleolus exercise)*

- twist, tighten, cut and lay against cortex

- back up pins, bend to create hook and cut
- push hook back into cortex to capture wire loop and bury the tip of the pin

** check fracture reduction and fixation with fluoroscopy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VII. MALLEOLAR FRACTURES

FIBULAR MALLEOLUS

VII.A.2. WEBER B (LONG - OBLIQUE SER)

Technique: *"anchor / compression" / (3) x 3.5 mm cortical screws*

Purpose:

- fixation of "long oblique" fracture with "anchor" and "compression" screw techniques ***(fig. A, B)***

Points of Instruction:

- anchor screw, mid point of the fracture, perpendicular to the long axis of the bone
- site of "head" and "thread" purchase is the shortest distance between two cortices, prevents telescoping...
- telescoping of the fracture would require pull out of the threads or pull through of the head

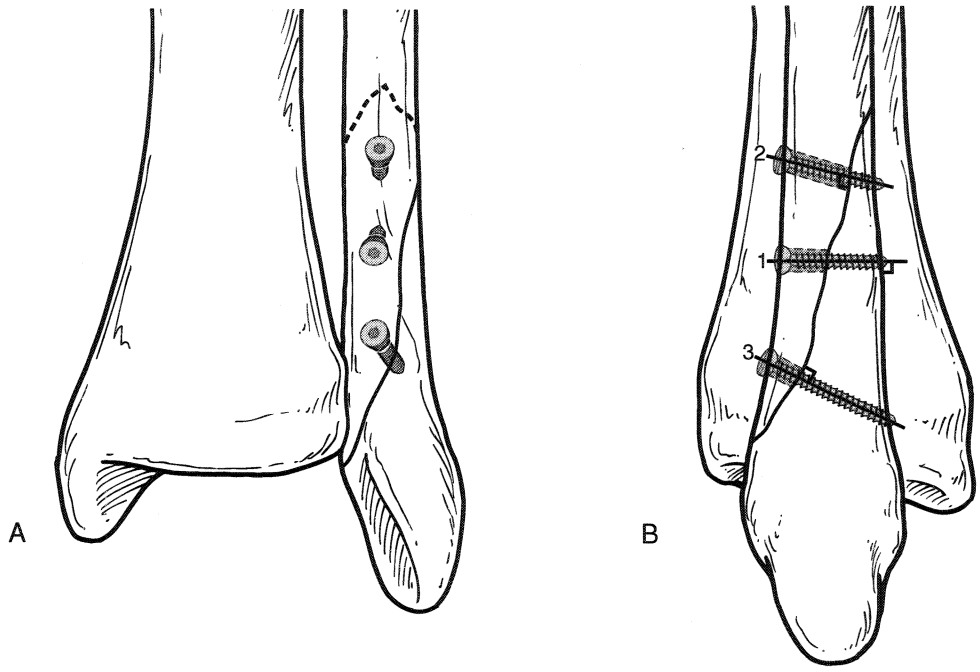
- compressions screws, perpendicular to fracture plane in sagittal and transverse orientations

1st screw - "anchor" screw ***(fig. B)***

2nd, 3rd screws - "compression" screws ***(fig. B)***

Insertion Sequence - 3.5 mm cortical screw ("small bone" lag screw technique)

- pre-drill	*1.6 mm K-wire (optional)*
- thread hole	2.5 mm drill bit
- countersink	
- overdrill	3.5 mm drill bit
- depth gauge	
- tap	3.5 mm cortical tap
- screw insertion	3.5 mm cortical screw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VII. MALLEOLAR FRACTURES

FIBULAR MALLEOLUS

VII.A.3. WEBER B (SHORT - OBLIQUE SER)

Technique: *3.5 mm interfragmental compression screw + "neutralization" plate*

PURPOSE:

- interfragmental compression with a single screw supported by a neutralization plate

- **Interfragmental compression** of short oblique fracture with a 3.5 mm cortical screw ***(fig. A)***

- Application of **Neutralization plate** ***(fig. B)***
  / lateral application 1/3 tubular plate with 3.5 mm cortical screws...

POINTS OF INSTRUCTION: ***(fig. B)***

- reduction of fracture with bone clamp

- insertion of interfragmental screw / anterior to posterior / perpendicular to the fracture

- selection of 5-hole 1/3 tubular plate *(at least 2 screws distal and proximal to the fracture)*
- no pre-bending required if the plate relatively matches the contour of the lateral surface of the fibula
- the plate is relatively malleable, but you may twist or bend if there is a significant discrepancy

- all screws inserted concentrically... NO axial compression... Neutralization plate
- proximal screws... 3.5 mm cortical screws... through both cortices
- distal screws... in softer distal fibula may be fully threaded cancellous screws
  through lateral cortex only

Interfragmental Compression Screw / 3.5 mm cortical screw

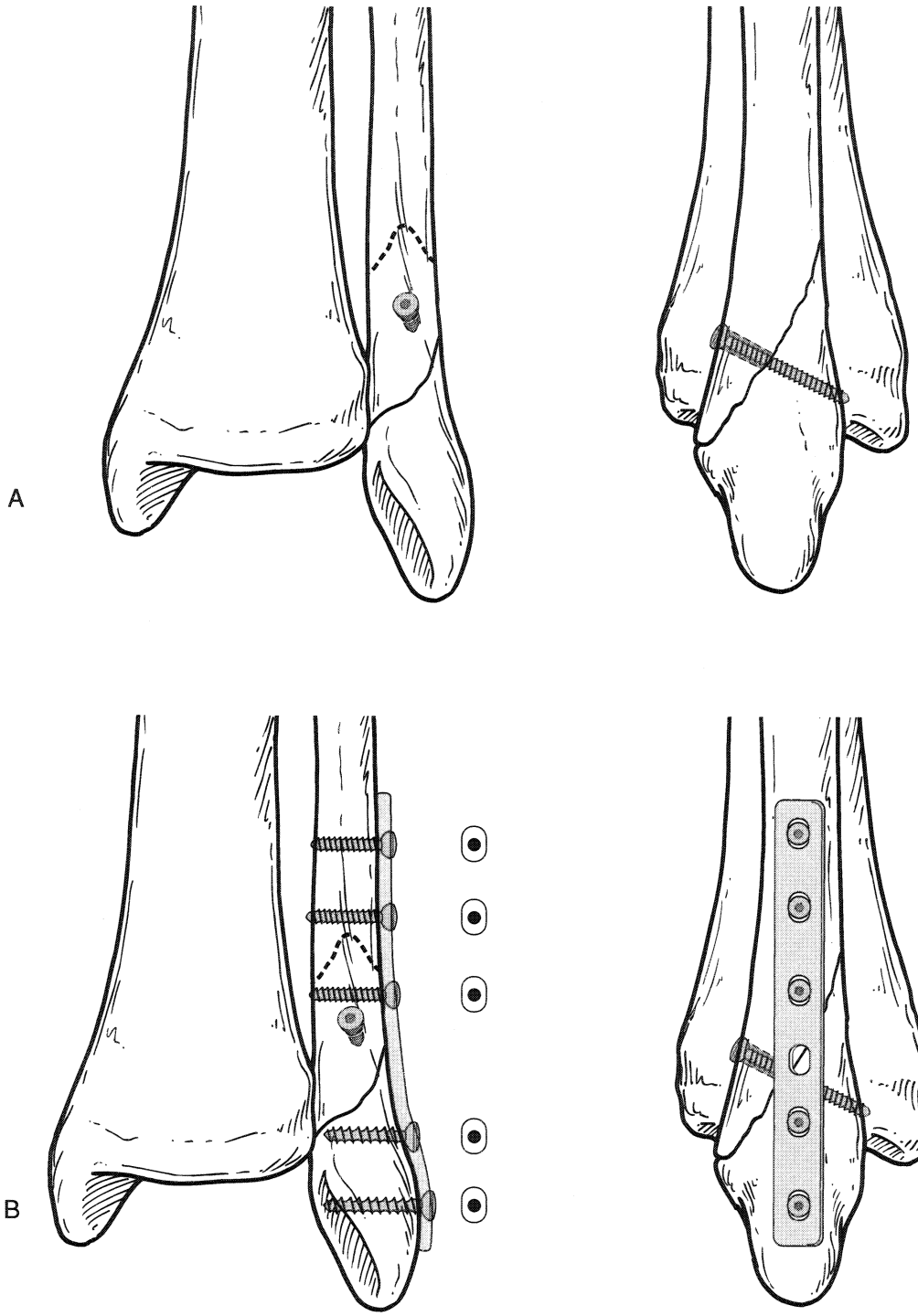
Insertion Sequence - "small bone" lag screw technique

Neutralization Plate Application / 1/3 tubular plate

"neutral application" / contour

"neutral" screw insertion

- **thread hole** - 2.5 mm drill bit *(centralized in each plate hole)*
- **depth gauge**
- **tap** - 3.5 mm cortical tap *(not necessary if using "self tapping" screws)*
- **screw Insertion** - 3.5 mm cortical screw


A
B

VII. MALLEOLAR FRACTURES

FIBULAR MALLEOLUS

VII.A.4. WEBER B (SHORT - OBLIQUE SER)

Technique: *Posterior "Anti-glide" plate*

PURPOSE:

- **buttress technique** to prevent shortening of an oblique fracture
  (used when bone quality of fibular malleolus may not be optimal)

- **plate and "trick" screw** capture the acute angle of the fracture fragment and prevents telescoping

POINTS OF INSTRUCTION:

- posterior application of 5-hole 1/3 tubular plate
  (may have to twist plate to match rotation of the posterior surface of the fibula)

- no interfragmental compression screw is utilized

- plate is positioned to span the point of the posterior proximal spike of the fracture ***(fig. A, B)***

- the most important screw is the screw in the plate just above posterior superior spike of the fracture

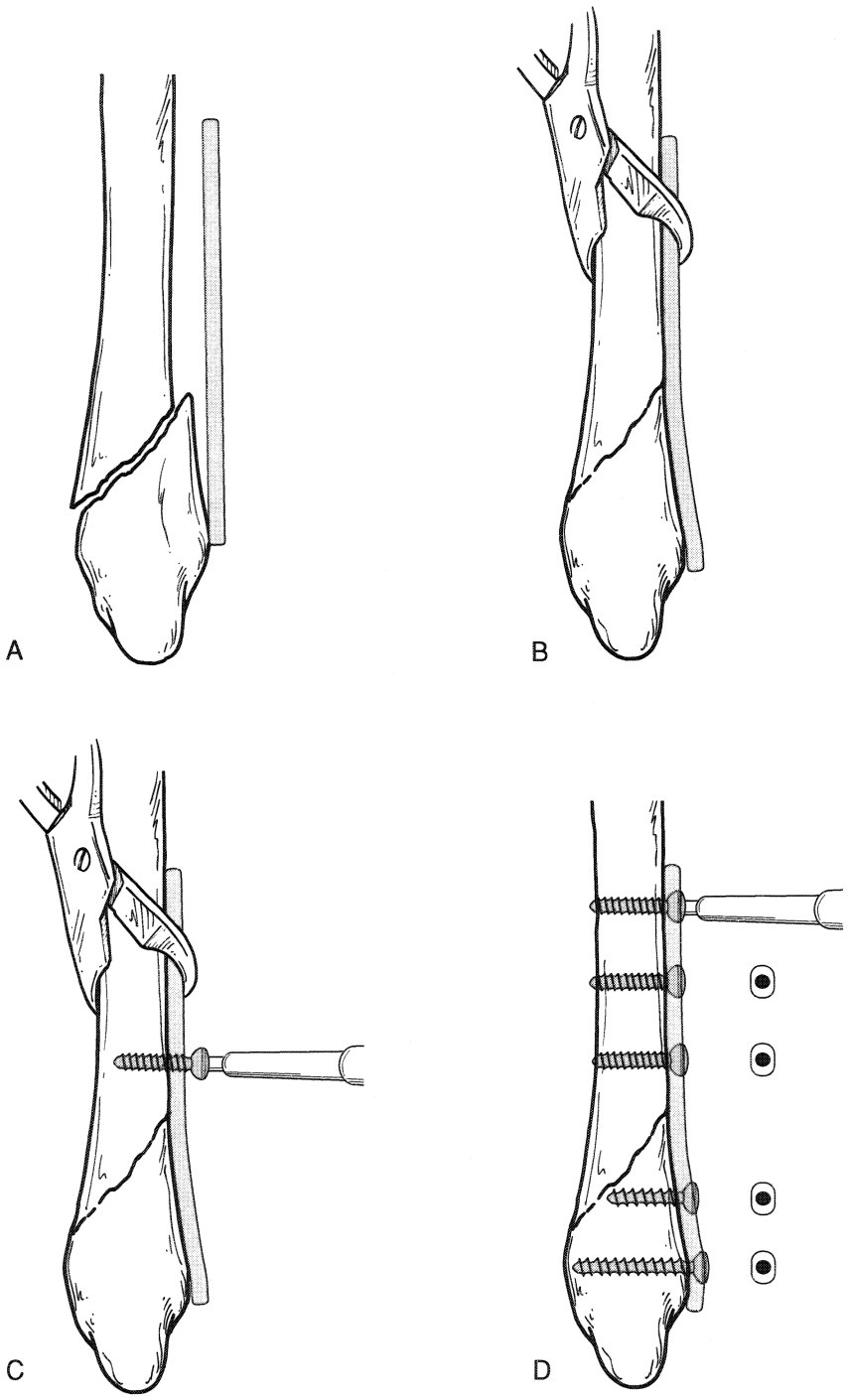
* **"trick" screw** is inserted and tightened to reduce the fracture ***(fig. C)***
  and capture the proximal spike to prevent telescoping or shortening of the fracture

- usually insert 3 screws above the fracture... inserted neutrally... ***(fig. D)***

- distal screws are optional / recommended ***(fig. D)***

"neutral" screw insertion

- **thread hole** - 2.5 mm drill bit *(centralized in each plate hole)*
- **depth gauge**
- **tap** - 3.5 mm cortical tap *(not necessary if using "self tapping" screws)*
- **screw Insertion** - 3.5 mm cortical screw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VII. MALLEOLAR FRACTURES

FIBULAR MALLEOLUS

VII.A.5. WEBER C *(high fibular fracture / comminuted, butterfly fragment)*

Technique: ✱ *1/3 tubular "Locking" plate / neutralization plate*
3.5 mm cortical "syndesmotic" screw

PURPOSE:

- incorporation of butterfly fragment and reduction of high fibular fracture with 3.5 mm "locking plate" ***(fig. A, B)***
- protection of fracture with application of a "neutral" 1/3 tubular "Locking" plate ***(fig. B)***
- syndesmotic repair technique / 3.5 mm cortical screw / 4 cortices ***(fig. C, D)***

POINTS OF INSTRUCTION:

- reduce and fixate butterfly with locking plate

- select a long, 8-hole, 1/3 tubular "Locking" plate / to be applied laterally as a neutralization plate

- all screws *(3.5 mm cortical)* are inserted with "locking" screw technique

Syndesmosis screw ***(fig. C, D)***

- 3.5 mm or 4.5 mm cortical screw
- 4 cortices

- above the syndesmosis

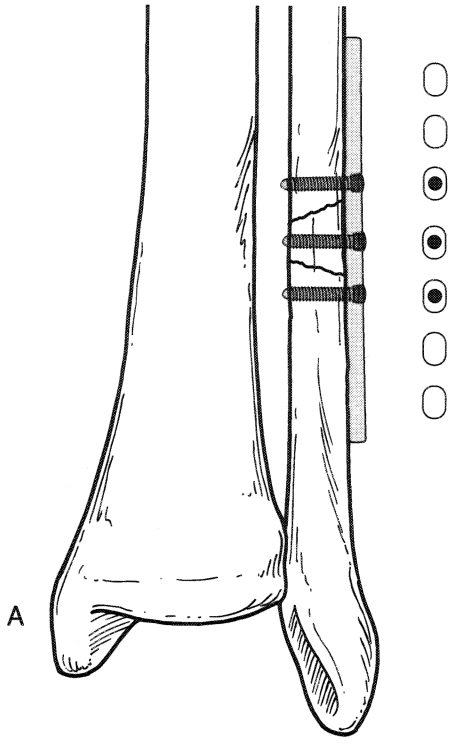
*** critical angulation 30° anterior

- trans-syndesmotic screw can be inserted through a hole in the plate, if necessary

**** maintain reduction of syndesmosis with "peri-articular" reduction clamp
while inserting the syndesmotic screw
** *(modification of the "compromise" compression technique)*

"syndesmotic" screw insertion sequence - 3.5 mm cortical screw

- thread hole	- 2.5 mm drill bit
- countersink	*(if not in hole of plate)*
- depth gauge	
- tap	- 3.5 mm cortical tap *(not necessary if using "self tapping" screws)*
- screw Insertion	- 3.5 mm cortical screw



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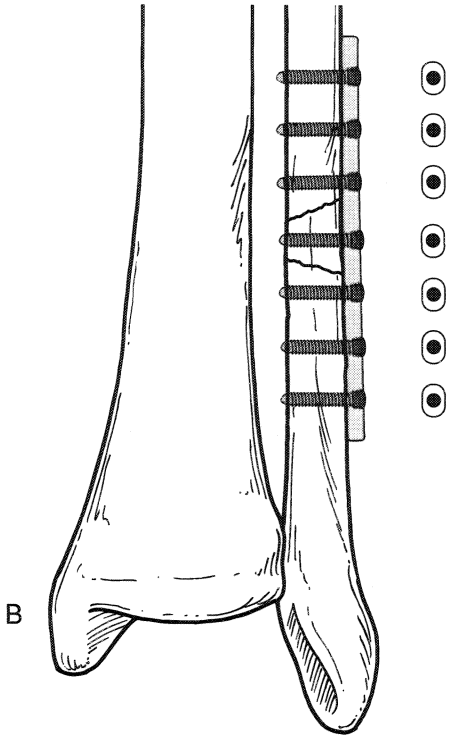

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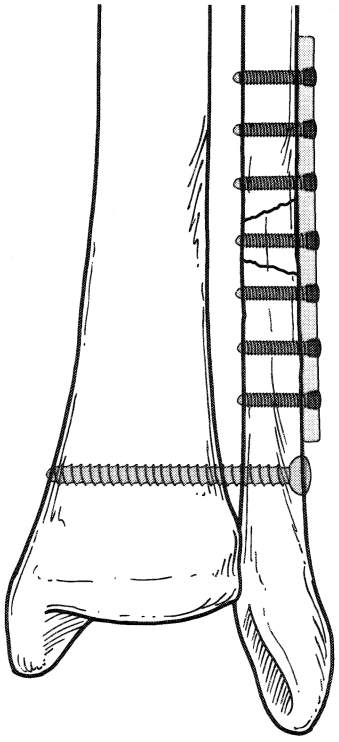

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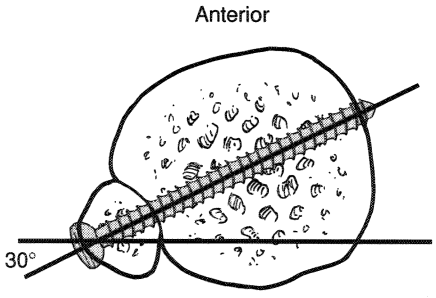


D

VII. MALLEOLAR FRACTURES

MEDIAL MALLEOLUS:

VII.B.1. MEDIAL MALLEOLUS (TRANSVERSE / AVULSION)

Technique: *K-wire splintage / tension band wire / "double twist" technique*

VII.B.2. MEDIAL MALLEOLUS (TRANSVERSE / AVULSION)

Technique: *(2) x 4.0 mm "partially threaded" cancellous screws*

VII.B.3. MEDIAL MALLEOLUS (VERTICAL / SHEAR)

Technique: *"Schuberth" Anti-glide plate + (2) x 4.0 mm cancellous screws*

VII. MALLEOLAR FRACTURES

VII.B.1. MEDIAL MALLEOLUS (TRANSVERSE / AVULSION)

Technique: *K-wire splintage / tension band wire / "double twist" technique*

PURPOSE:

- K-wire splintage with **double twist** tension band technique

POINTS OF INSTRUCTION:

- reduce medial malleolar with bone clamp

- temporary fixation with 1.6 mm K-wires
- use of parallel drill guide
- **orientation of the pins** is in a horizontal plane, parallel with medial cortex of the tibia ***(fig. A)***
- **perpendicular to the fracture line**

- a drill hole is then made from posterior to anterior "equidistant" above the fracture line ***(fig. A)***

*** **DOUBLE TWIST TECHNIQUE** ***(fig. B - E)***

- pass 22 ga. / 1.0 mm monofilament wire with pre-made twist through drill hole

- loop around pins in a figure "8" pattern

- tighten with a single twist technique on opposite side from the original twist

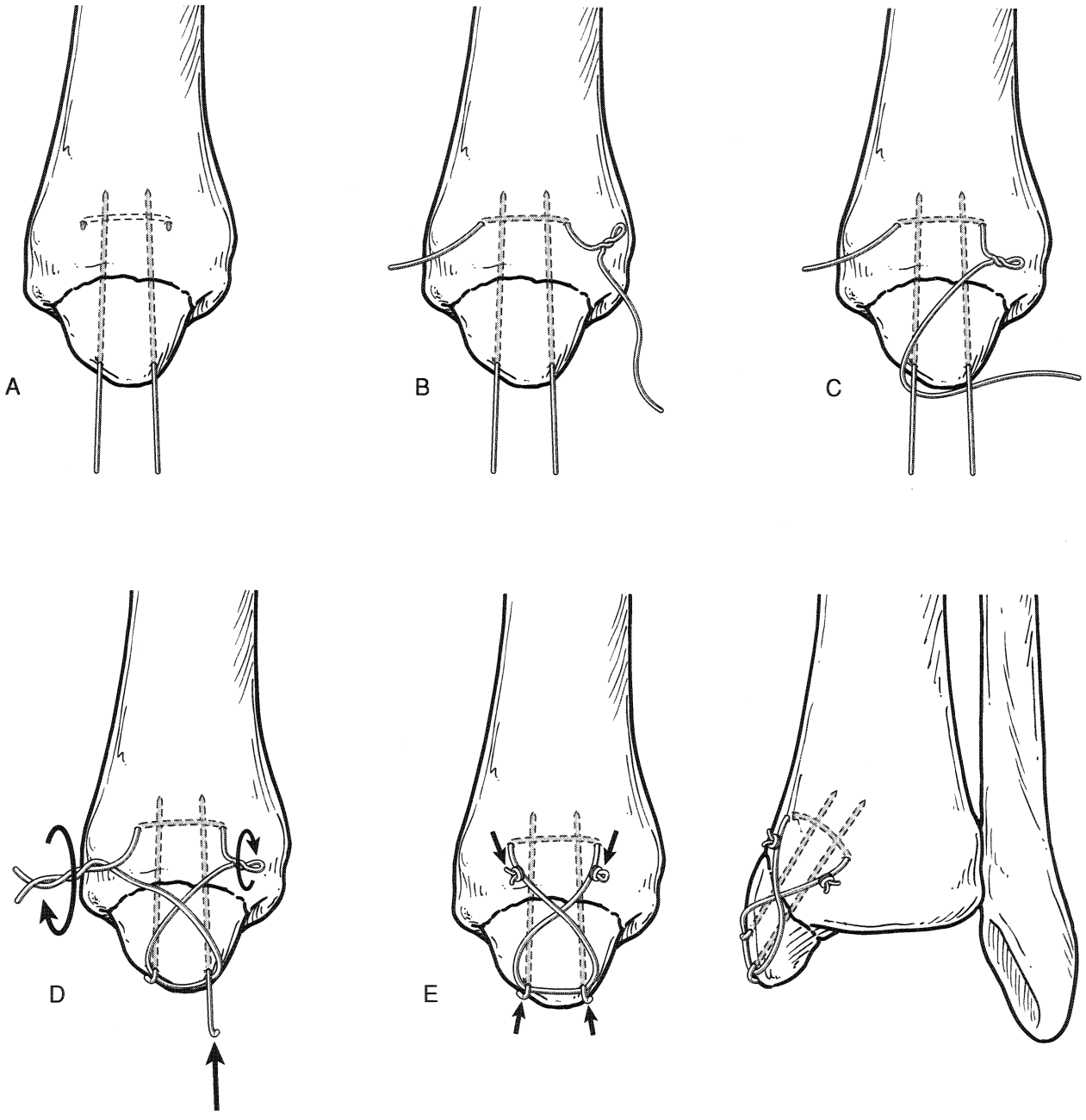
- both "knots" should be tightened / twisted at the same time
  "this requires 2 surgeons pulling the wire parallel to the superior arm of the wire as they twist"
  this technique is necessary to evenly take up the slack in the loop and evenly tighten the wire across the fracture, creating even compression across the fracture

- twist, tighten, cut and lay against cortex

- back up pins, bend to create hook and cut

** check fracture reduction and fixation with fluoroscopy

*** **alternative technique** for securing the wire above the fracture
- insert a 3.5 mm screw and loop the wire around the head of the screw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VII. MALLEOLAR FRACTURES

VII.B.2. MEDIAL MALLEOLUS (TRANSVERSE / AVULSION)

Technique: *(2) x 4.0 mm "partially threaded" cancellous screws*

PURPOSE:

- (2) screw fixation technique of medial malleolar fracture (4.0 mm cancellous screws) ***(fig. A, B)***

POINTS OF INSTRUCTION:

- reduce the fracture with a bone clamp

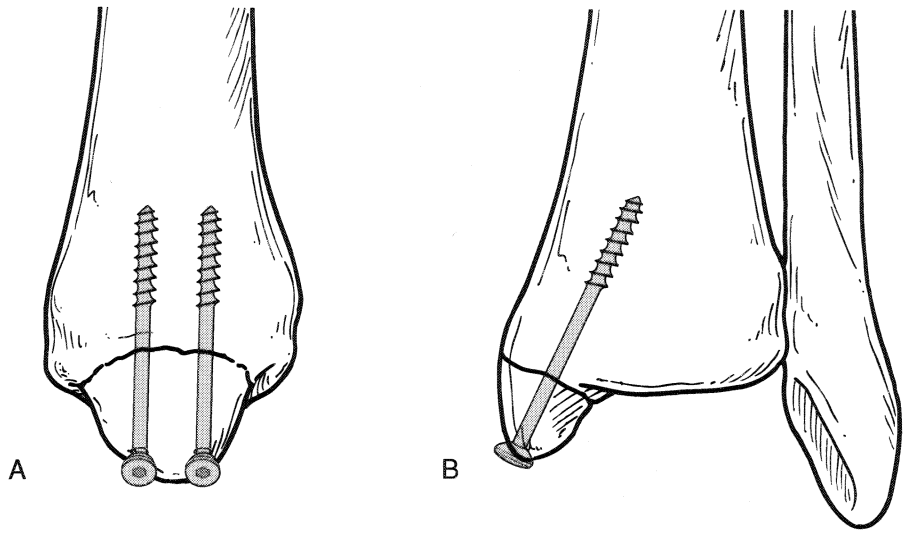
- temporary fixation with 1.6 mm K-wires (horizontal orientation)
- use of parallel drill guide

- **orientation of pins:**
- parallel to the medial cortex of the tibia
- perpendicular to the fracture line

- insert (2) 4.0 mm "partially threaded" cancellous screws in temporary pin sites

Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- pre-drill	1.6 mm K-wire *(use of parallel drill guide is optional)*
- thread hole	2.5 mm drill
- countersink	*(keep in line with thread hole)*
- depth gauge	
- tap	4.0 mm cancellous tap *(1.75 mm pitch)*
- screw insertion	4.0 mm "partially threaded" cancellous screw


A
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VII. MALLEOLAR FRACTURES

VII.B.3. MEDIAL MALLEOLUS (VERTICAL / SHEAR)

Technique: *"Schuberth" Anti-glide plate + (2) x 4.0 mm "partially threaded" cancellous screws*

PURPOSE:

- (2) screw fixation technique of medial malleolar fracture *(4.0 mm cancellous screws)*

*** single hole plate application to capture proximal edge of fracture
to prevent telescoping or proximal shift of the vertical fracture line

POINTS OF INSTRUCTION:

- reduce fracture with bone clamp

Temporary fixation with 1.6 mm K-wires ***(fig. A)***

- use of parallel drill guide
- **orientation of pins** / horizontal or vertical dependent upon the anatomy of the fracture
- **perpendicular to the fracture line**

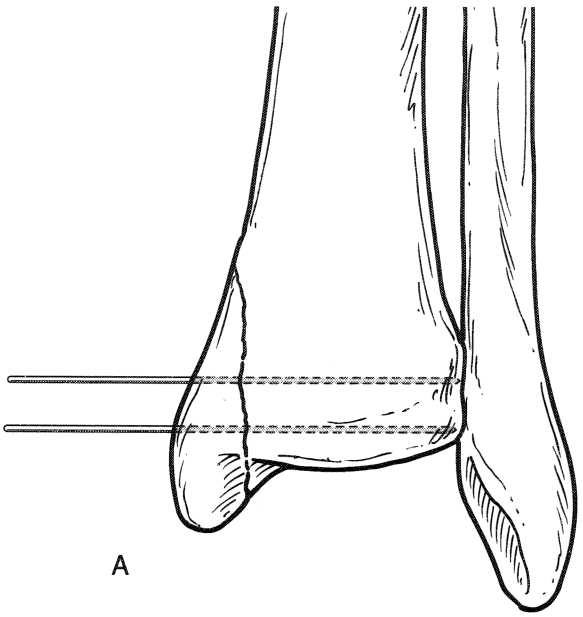
Application of "Anti-Glide" Plate ***(fig. B)***

- span a (2) hole, 1/3 tubular plate across the proximal edge of the fracture
- fixate to the bone with (2) parallel 3.5 mm cortical screws

Insertion of (2) 4.0 mm "partially threaded" cancellous screws in temporary fixation sites ***(fig. C)***

Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- **thread hole** 2.5 mm drill
- **countersink** *(keep in line with thread hole)*
- **depth gauge**
- **tap** 4.0 mm cancellous tap (1.75 mm pitch)
- **screw insertion** 4.0 mm "partially threaded" cancellous screw



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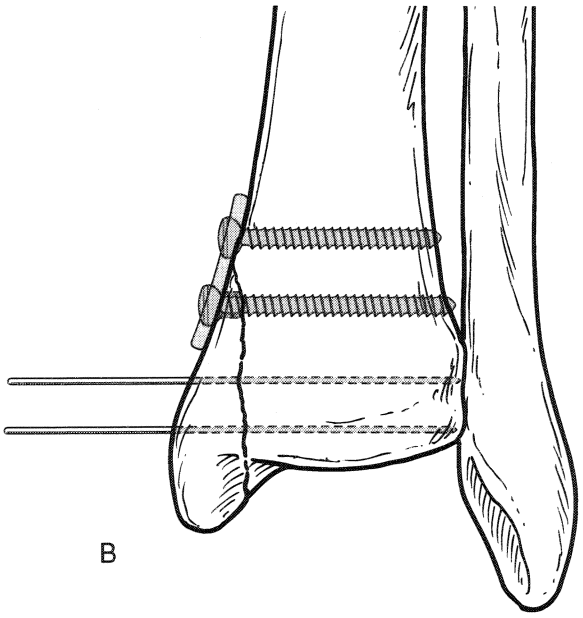

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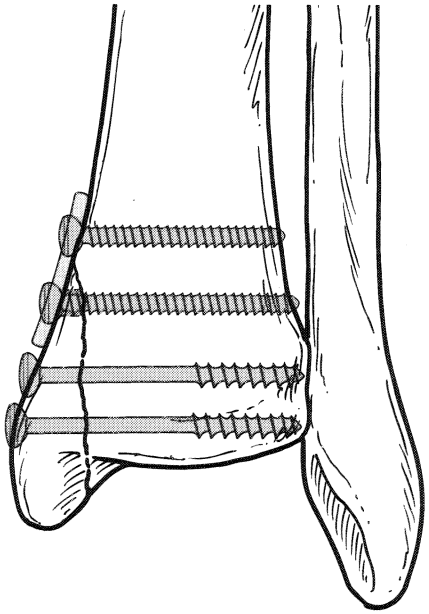


C

VII. MALLEOLAR FRACTURES

POSTERIOR MALLEOLUS

VII.C.1. POSTERIOR MALLEOLUS - "DIRECT"

Technique: *4.0 mm cannulated "partially threaded" cancellous screw*

VII.C.2. POSTERIOR MALLEOLUS - "INDIRECT"

Technique: *4.0 mm "fully threaded" cancellous screw*

VII. MALLEOLAR FRACTURES

VII.C.1. POSTERIOR MALLEOLUS - "DIRECT"

Technique: *4.0 mm cannulated "partially threaded" cancellous screw*

PURPOSE:

- direct, posterior technique for fixation of the posterior malleolus

POINTS OF INSTRUCTION:

Posterior / Direct Approach

- exposure from between the peroneal tendons and the Achilles tendon

- reduce the fracture with a bone clamp

- make sure that the drill and/or screw does not enter the ankle joint

- **perpendicular to the fracture line**
  (posterior / inferior / lateral to anterior / superior / medial)

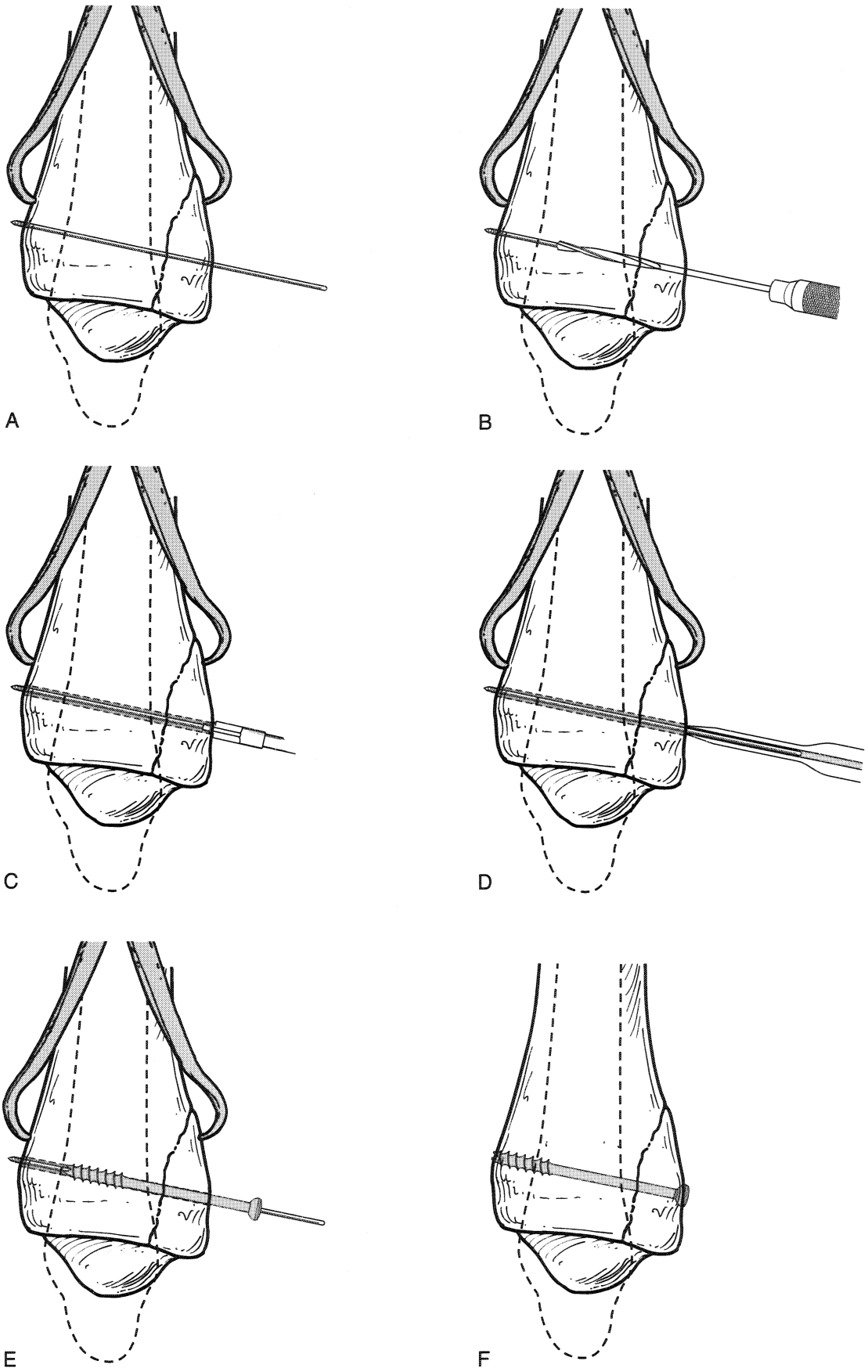
Insertion Sequence - 4.0 mm cannulated "partially threaded" cancellous screws

- guide wire	1.25 mm threaded tip guide wire	***(fig. A)***
- thread hole	**Optional drilling of proximal cortex in hard cortical bone*	***(fig. B)***
- countersink		***(fig. C)***
- external measuring device		***(fig. D)***
- *screw insertion	4.0 mm cannulated screw *(self-drilling, self-tapping)*	***(fig. E, F)***

**** **non cannulated, regular 4.0 cancellous screws may also be used***

Insertion Sequence - 4.0 mm "partially threaded" cancellous screw (SFS)

- thread hole	2.5 mm drill
- countersink	*(keep in line with thread hole)*
- depth gauge	
- tap	4.0 mm cancellous tap *(1.75 mm pitch)*
- screw insertion	4.0 mm "partially threaded" cancellous screw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VII. MALLEOLAR FRACTURES

VII.C.2. POSTERIOR MALLEOLUS - "INDIRECT"

Technique: *4.0 mm "fully threaded" cancellous screw*

PURPOSE:
- anterior, indirect technique for fixation of the posterior malleolus

POINTS OF INSTRUCTION:
- use of a fully threaded cancellous screw in metaphyseal bone with modification of technique by using a 4.0 mm drill to create a "glide hole" and create interfragmental compression with a fully threaded cancellous screw

Anterior / Indirect Approach
- reduce fracture with pelvic bone clamp ***(fig. A)***

- drill thread hole with 2.5 mm drill through anterior and posterior fragments, countersink as usual ***(fig. A, B)***

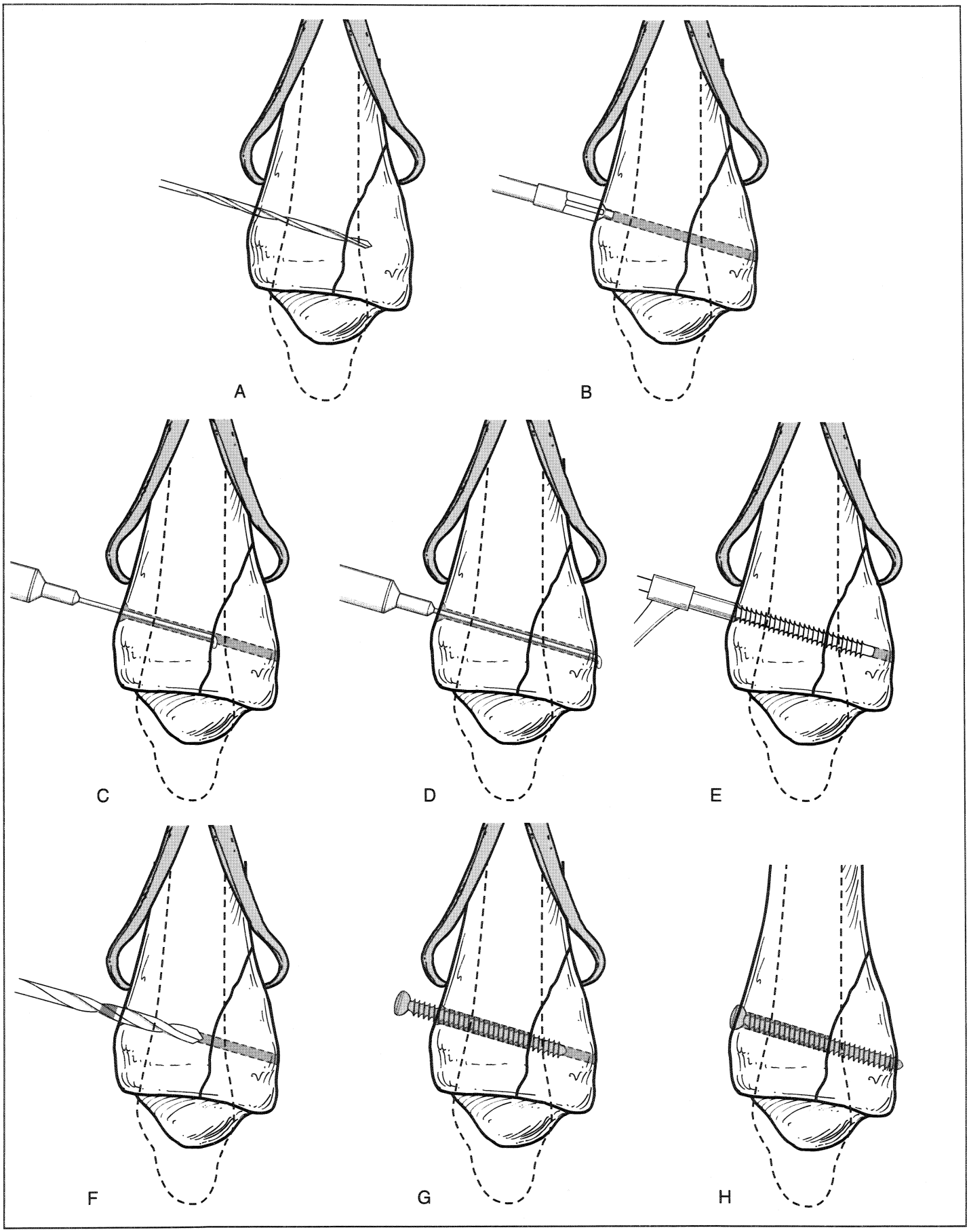
*use of depth gauge to measure the depth of the anterior fragment and determine the depth of the glide hole ***(fig. C, D)***

mark the 4.0 drill to control the depth of penetration for overdrill the anterior fragment only *(fig. F)***

- complete the sequence with insertion of the 4.0 mm fully threaded cancellous screw ***(fig. G, H)***

Insertion Sequence - 4.0 mm "fully threaded" cancellous screw (SFS)

- thread hole	2.5 mm drill	***(fig. A)***
- countersink	*(keep in line with thread hole)*	***(fig. B)***
- depth gauge		
	- measure anterior segment	***(fig. C)***
	- measure full depth of distal tibia	***(fig. D)***
- tap	4.0 mm cancellous tap *(1.75 mm pitch)*	***(fig. E)***
- *overdrill	4.0 mm drill ****mark the depth of the anterior fragment on the drill bit to control depth of penetration so that the "overdrill" does not penetrate into the distal fragment***	***(fig. F)***
- screw insertion	4.0 mm "fully threaded" cancellous screw	***(fig. G, H)***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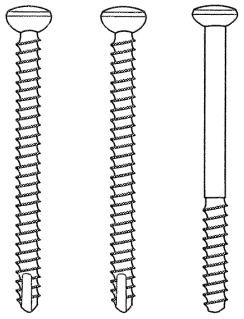
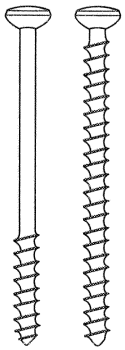
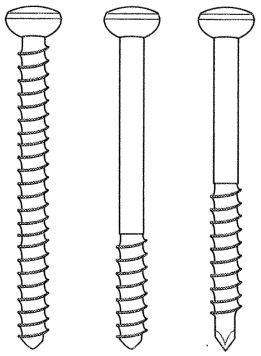
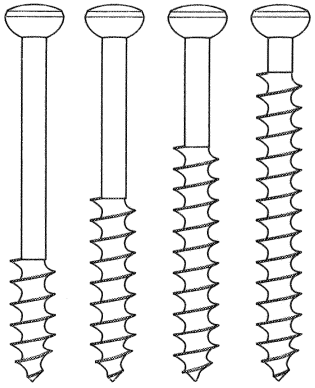
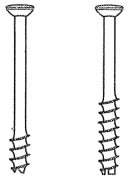
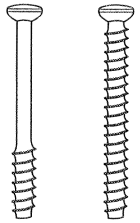
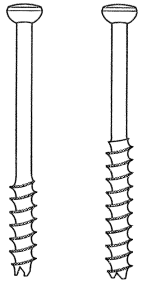
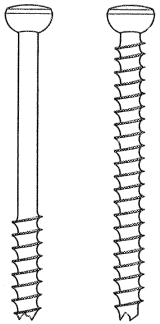
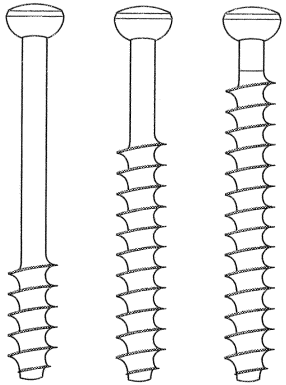
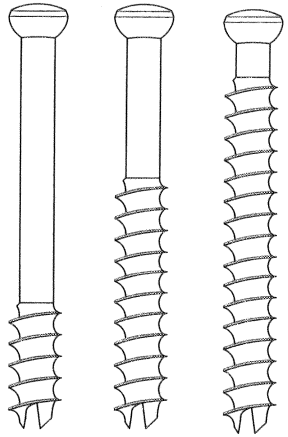
G
H

Screws, Drill Bits and Taps (Self-tapping and Non-self-tapping screws)

SCREW DIAMETER (mm)																
Tread Diameter	**2.0**	**2.4**	**2.7**	**3.5**			**4.0**		**4.5**			**6.5**			
Screw Type	**Cortex, self-tapping**			**Cortex**	**Pelvic Cortex**	**Shaft**	**Cortex**	**Cancellous** Non-self-tapping	**Cortex**	**Shaft**	**Malleolar**	**Cancellous** Non-self-tapping			
	and Non-self-tapping	---	and Non-self-tapping	Self-tapping and Non-self-tapping	Self-tapping	Non-self-tapping	Self-tapping	Partial thread / Full tread	Self-tapping and Non-self-tapping	Non-self-tapping	Non-self-tapping	16 mm Thread	24 mm Thread	32 mm Thread	Full Thread
DRILL BIT and TAP DIAMETER (mm)															
Drill Bit for Gliding Hole	**2.0**	**2.4**	**2.7**	**3.5**			**4.0**	**---**	**4.5**			**4.5** in hard bone			
															
Drill Bit for Threaded Hole	**1.5**	**1.8**	**2.0**	**2.5**			**2.9**	**2.5**	**3.2**			**3.2**			
Tap (in hard bone and for non- tapping screws)	**2.0**	**---**	**2.7**	**3.5**			**4.0**	**4.0**	**4.5**			**6.5**			
Drive Type	1.5 mm/ 2.0 mm Cruciform	2.4 mm Cruciform	2.5 mm Hex	2.5 mm Hex			2.5 mm Hex		3.5 mm Hex			3.5 mm Hex			

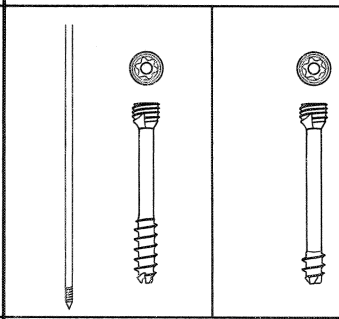
Cannulated Screws, Guide Wires, Drill Bits and Taps

SCREW DIAMETER (mm)														
Tread Diameter	**3.0**		**3.5**		**4.0**		**4.5**		**7.0**			**7.3**		
Screw Type	**Cancellous** Self-drilling Self-tapping		**Cortex**		**Cancellous** Self-drilling Self-tapping		**Cancellous** Self-drilling Self-tapping		**Cancellous**			**Cancellous** Self-drilling Self-tapping		
Thread Length	Short	Long	Partial	Full	Short	Long	Partial	Full	16 mm	32 mm	Full	16 mm	32 mm	Full
Guide Wire, Drill Bit and Tap Diameter (mm)														
Guide Wire	**1.1**		**1.25**		**1.25**		**1.6**		**2.0**			**2.8**		
Drill Bit for Gliding Hole (in hard bone)	- - -		**3.5**		- - -		**4.5**		- - -			- - -		
														
Drill Bit for Threaded Hole	**2.0**		**2.7**		**2.7**		**3.2**		**4.5**			**5.0**		
Tap (in hard bone)	- - -		**3.5**		**4.0**		**4.5**		**7.0**			**7.3**		
Drive Type	3.0 mm Cruciform		2.5 mm Hex		2.5 mm Hex		3.5 mm Hex		3.5 mm Hex			4.0 mm Hex		

Locking Plate Screws, Guide Wires, Drill Bits and Taps

SCREW DIAMETER (mm)		
Tread Diameter	**3.5**	
Locking Screw Type	**Locking Head**	
	Solid Self-tapping	
Thread Length	Full	
Drill Bit and Tap Diameter (mm)		
Guide Wire	- - -	- - -
		
Drill Bit for Threaded Hole	**2.8**	
Tap (in hard bone)	- - -	
Drive Type	2.5 mm Hex	T15 StarDrive™

Cannulated Headless Compression Screws, Guide Wires and Drill Bits

SCREW DIAMETER (mm)		
Proximal Tread Diameter	**3.5**	
Distal Tread Diameter	**3.0**	
Screw Type	**Cancellous** Self-drilling, Self-tapping	
Thread Length	Long	Short
Guide Wire, Drill Bit and Tap Diameter (mm)		
Guide Wire	**1.1**	
		
Drill Bit for Threaded Hole	**2.0 Cannulated**	
Tap (in hard bone)	- - -	
Drive Type	T8 StarDrive™	

Screw Dimensions

SCREW DIAMETER (mm)							
Tread Diameter	**6.5**	**4.5**	**4.0**	**3.5**	**2.7**	**2.0**	**1.5**
Screw Type	**Cancellous** (Partial thread / Full tread)	**Cortex**	**Cancellous** (Partial thread / Full tread)	**Cortex**	**Cortex**	**Cortex**	**Cortex**
Core Diameter	**3.0**	**3.0**	**2.0**	**2.4**	**1.9**	**1.3**	**1.0**
Shank Diameter	**4.5**	**---**	**2.3**	**---**	**---**	**---**	**---**
Pitch	**2.75**	**1.75**	**1.75**	**1.25**	**1.0**	**0.6**	**0.5**