

COMPLICATIONS OF INTERNAL FIXATION

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INTRODUCTION

Internal fixation is an area of surgical specialty intended to facilitate osseous union. This process utilizes atraumatic surgical technique and accurate anatomic reduction to incorporate a fixation device across a fracture, osteotomy or arthrodesis site. The primary goal of internal fixation is to increase stability and promote osseous healing in a functioning position.

Upon determining a method of treatment, surgical vs. conservative, all potential complications and risks should be considered and weighed against possible benefits. Internal fixation is a process requiring surgical intervention, therefore, all surgical and anesthetic risks that accompany any surgical procedure should be considered in addition to the specific complications of internal fixation.

The purpose of this presentation is to increase awareness of potential complications. Mechanical and technical complications resulting in instability and subsequent non-union will be of primary focus, but all complications inherent to incorporation of a fixation device will be addressed. Other surgical and anesthetic risks will not be discussed.

This presentation is divided into a review of commonly utilized fixation devices of podiatric surgery, complications inherent to the implant (IF device) and complications secondary to inappropriate application. Due to the technical aspects of AO fixation an additional discussion is devoted to failure of plates and screws.

FIXATION DEVICES

Although there are many generic complications for various internal fixation devices, each specific device has innate limitations and potential complications. Internal fixation commonly utilized in podiatric surgery includes, Kirschner wires/ Steinmann pins, staples, surgical stainless steel wire, screws, plates, and absorbable pins.

I. KIRSCHNER WIRES / STEINMANN PINS

A. Properties

1. Stainless steel pins
2. Many diameters available (k-wires are thinner than Steinmann pins.
3. Threaded or smooth
4. Strength varies with size (Steinmann pins are more rigid and stronger)

B. Advantages

1. Easiest fixation device utilized
2. Minimal exposure required
3. Good for small fractures
4. Good for temporary fixation
5. Multiple pins may be utilized
6. Removed easily

C. Disadvantages

1. No compression (except with special circumstances and techniques.
2. One pin limits motion in only two planes.

D. Potential Complications

1. Migration most common with smooth k-wire
2. If percutaneous, pin tract infection

II. STAPLES

A. Properties

1. Metallic devices with two, three or four prongs connected with a horizontal bar
2. U-shaped two prong device is most common
3. Variety of sizes available
4. Inserted manually or with pneumatic power gun
5. Staples with barbs on prongs are available

B. Advantages

1. Quick and easy insertion
2. Prevents distraction
3. Multiple staples may be utilized to resist rotation

C. Disadvantages

1. No compression
2. One staple only limits motion in one or two planes

D. Potential Complications

1. Displacement upon insertion
2. Additional fracture created upon insertion
3. Migration - risk decreased with barbed staples

III. SURGICAL STAINLESS STEEL WIRE

A. Properties

1. Various sizes available - ranges from 18 gauge to 30 gauge
2. May be utilized single or double strand
3. Pliable

B. Advantages

1. Small amount of foreign material incorporated
2. Multiple techniques of application available (cerclage, figure of eight and tension banding).
3. Good as an adjunctive device in severely comminuted fractures
4. Easily used in addition to other devices for increased stability

C. Disadvantages

1. No compression unless used as tension band
2. Limits motion in one dimension. Multiple wires needed for a complete fracture.

D. Potential Complications

1. Compromised strength with aggressive twisting. May break intra-op or post-op.

IV. SCREW FIXATION

A. Properties

1. Stainless steel
2. Multiple types available (cortical, cancellous, malleolar, cannulated and selftapping)
3. Multiple sizes available

B. Advantages

1. Interfragmental compression
2. Early ROM post-op

C. Disadvantages

1. Precise technique required
2. Compromised in osteoporotic bone more than other devices
3. Increased tissue dissection
4. Variations of an osteotomy may be necessary to accommodate appropriate orientation of a screw

D. Potential Complications

1. Additional fracture with insertion
2. Irritation from prominent screw head
3. Implant induced osteoporosis
4. Failure to achieve compression
5. Stress risers

V. PLATE FIXATION

A. Properties

1. Stainless steel
2. Wide variety of shapes and sizes

B. Advantages

1. May create compression
2. Can be used in combination with inter-fragmentary screw fixation
3. Early ROM post-op
4. Resist motion in three dimensions

C. Disadvantages

1. Increased dissection
2. Longer operative time
3. Frequently, second operation required for removal
4. A large amount of foreign material

D. Potential Complications

1. Prominence with superficial irritation
2. Implant induced osteoporosis
3. Multiple stress risers / Fracture or refracture

VI. ABSORBABLE PINS

A. Properties

1. Two types available
 - a. Orthosorb[®] - PDS
 - b. Biofix[®] - self-reinforced PGA
2. Gradual loss of strength

3. Totally absorbed by hydrolysis
 4. Multiple sizes of Biofix available
- B. Advantages
1. Removal not required
 2. No continued stress protection
- C. Disadvantages
1. Not radiopaque
 2. Expensive
 3. Less strength than metallic counterpart
- D. Potential Complications
1. Sterile abscess with severe inflammatory reaction
 2. Inadequate placement cannot be evaluated radiographically

IMPLANT (INTERNAL FIXATION DEVICE) COMPLICATIONS

The incorporation of a foreign material for fixation has several potential complications. Some specific problems include bioincompatibility, allergic response and carcinogenic potential. Implanted materials may also be a hidden focus for infection or create osteoporosis around the device. Occasionally the potential for migration of a fixation device through bone or soft tissue is present.

I. IMPLANT COMPLICATIONS

A. Bio-Incompatibility

1. Most stainless steel implants available today are extremely inert
2. Reaction very rare to metal devices unless true allergy
3. Absorbable fixation has been shown to create sterile abscess with severe inflammatory reaction

B. Allergic Response

1. Reaction usually secondary to sensitivity to one of the metal components of stainless steel (nickel, chromium, molybdenum and occasionally titanium)
2. Nickel sensitivity most common
3. Titanium sensitivity least common
4. Cutaneous or systemic hypersensitivity reactions may occur
5. Eczema is the most frequent reaction
6. Other reactions occurring include urticaria, non-eczematous bullous reactions and vasculitis

7. Time interval for development of cutaneous reaction is usually long
8. Cutaneous reactions will persist until implant removed

C. Malignancy

1. Rare - approximately 15 reported cases of malignancy occurring at site of metallic implant
2. Studies with laboratory animals have shown carcinogenic potential of implants with various metals
3. Increased duration of implanted material will increase risk

D. Infection

1. Recommendation for removal of fixation is controversial
2. Approach to postoperative infection is addressed in infection section of book

E. Osteoporosis

1. 1st observed around 6th week post implantation
2. Controversy over etiology. Stress protection vs. vascular compromise around implant
3. May occur with any type of fixation
4. Temporary if hardware removed

F. Migration

1. Smooth k-wires most susceptible
2. Motion occurring close to fixation increases risk
3. Incidence may be reduced by
 - a. Bending end of k-wire
 - b. Prompt removal
 - c. Prevent thermal necrosis of bone upon application

IATROGENIC COMPLICATIONS

Each internal fixation device available has inherent disadvantages and risks. However, the primary complications of internal fixation, non-union, delayed union and mal-union are often secondary to poor surgical technique or judgement. A surgeon must identify the risk and limitations of each device so that proper application will be administered.

Complications such as arthritic development in non-involved joints, neuropraxia and osteonecrosis may also be secondary to surgical technique upon internal fixation application.

I. IATROGENIC COMPLICATIONS

- A. Poor Material Selection
 - 1. Defective material
 - a. Early fatigue and breakage
 - b. Increased corrosion and increase tissue reaction
 - c. Rare occurrence due to improved material and increased regulation
 - 2. Inappropriate Size
 - a. Too thin may bend or break
 - b. Too large may create additional fractures
 - 3. Inappropriate Device
 - a. Complete fractures require increased stability in all plans. Devices limiting motion in one or two planes may be inadequate.
- B. Poor Maintenance of Fracture Fragment Approximation
 - 1. Inadequate intraoperative reduction
 - a. Angulated
 - b. Gapped
 - c. Shortened
 - 2. Poor temporary fixation
 - a. Loss of reduction as permanent fixation is applied
 - 3. Soft tissue or hematoma interposed between fragments
 - 4. Poor orientation or placement of fixation
 - a. Single k-wire will allow movement along pin axis
 - b. Fixation on compression side has minimal benefit
 - 5. Poor security of fixation
 - a. Loose secondary to burning of bone with drilling
 - b. Multiple drilling or multiple attempts of fixation placement compromises bone
 - c. Inadequate fixation for osteoporotic bone
- C. Inadequate Surgical and/or Fixation Technique
 - 1. Required number of cortices not purchased
 - 2. Excessive stripping of periosteum or soft tissue attachments leading to osteonecrosis

- 3. Arthritic changes in non-affected joints due to accidental invasion with internal fixation
 - 4. Improper positioning of internal fixation with resulting prominence externally
 - 5. Fixation in close proximity to neurovascular structures leading to neuropraxia
- D. Inadequate Post-op Control
 - 1. Inappropriate weightbearing
 - 2. Aggressive physical therapy

FAILURE OF AO DEVICES

In 1958 the AO group was established with the purpose of developing an ideal material and technique for fixation. With continued research and development, today's materials and techniques are far superior in achieving rigid fixation, however, complications resulting in instability continue to occur. Both failure of the implant and failure of the internal fixation process to obtain stability are seen.

The application of screws and plates require more technical expertise than other types of fixation. It is recommended that workshops directed toward use of AO fixation be attended prior to clinical application.

I. IMPLANT FAILURE (BREAKAGE)

- A. Natural weak points
 - 1. Run out of the screw
 - 2. Hole of a plate
- B. Defective material
 - 1. Rare
- C. Stress
 - 1. Overzealous bending of plate while contouring to bone
 - 2. External forces around fixated site too great for selected size of implant
 - 3. Inappropriate post-op management (ie. allow weightbearing with tib-fib transfixation screw)

Clinical Notes:

Breakage of an implant, either intra-op or postop, does not mandate removal. Other circumstances such as location of the broken device or status of the fixated part should be assessed. Frequently, postoperative breakage is associated with motion and therefore, non-union or delayed union should be considered.

II. INTRAOPERATIVE INTERNAL FIXATION FAILURE

A. Improper Selection

1. Cortical vs Cancellous screws
2. Number and size of screws utilized
 - a. If too few and/or too small, extrinsic forces will prevent stability
3. Length of plate
4. Orientation of screws
 - a. Perpendicular to fracture
 - b. Perpendicular to cortex

Clinical Note:

The AO group has designed guidelines for the proper selection of each of the above situations with many types of fractures. Knowledge of these guidelines is mandatory prior to use of screws and plates.

B. Technical Application

1. Instrumentation
 - a. Incorrect sequence
 - b. Incorrect size of an instrument utilized
 - c. Inappropriate countersinking
 1. Over countersinking will compromise the cortex and subsequently lose compression
 2. Under countersinking will not disperse head pressure and will result in fracture
 - d. Breakage of instrument may occur if excess torque utilized upon insertion
2. Screw Insertion
 - a. Non-purchasing screw could be result of one of several factors:
 1. Short screw
 2. Screw riding the intramedullary canal
 3. Stripped thread hole
 4. Fractured distal cortex
 5. Inappropriate direction of screw resulting in missing the far cortex
 - b. Screw tightens but no compression could be result of
 1. Improper overdrill
 2. Shank not crossing the osteotomy
 3. Screw riding intramedullary canal

Clinical Note:

If screw does not purchase or does not achieve compression, all of the above factors should be assessed to determine whether a longer screw is

necessary, if the screw needs to be redirected or if an larger diameter screw is required.

C. Plate Bending

1. Poor contouring of a plate for the specific site of application may create torque across the fracture site, resulting in distraction.

III. POSTOPERATIVE FAILURE OF INTERNAL FIXATION

A. Improper Selection

1. Inappropriate selection of any of the factors discussed with intra-op failure may initially appear adequate but fail during post-op course

B. Postoperative Management

1. Inappropriate weightbearing
2. Aggressive physical therapy

CONCLUSION

Many internal fixation complications occur. Some complications are inherent to the device or tissue incompatibility, but most are secondary to inappropriate use of the fixation device. Non-union resulting from failed stability is the primary complication. With increased knowledge of the limitations of each device, and with prudent judgement upon application, internal fixation complications can be minimized.

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