

# HANDBOOK OF Fractures

SIXTH EDITION



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# Handbook of Fractures

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*To my family, Lori, Alexander, Jonathan, and Gabrielle, and to my mentors, KJK, JDZ, and MJB.*

— KENNETH A. EGOL

*To my children who are constants in my life and have always been there for me. Thank you Courtney, Michael, and Lauren. And to my parents who provided me guidance and inspiration throughout my life.*

— KENNETH J. KOVAL

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— JOSEPH D. ZUCKERMAN



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Congruity  
Surgical Approaches  
Postoperative Care

COMPLICATIONS

**27. Hip Dislocations**

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

ANTERIOR DISLOCATIONS

POSTERIOR DISLOCATIONS

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

THOMPSON AND EPSTEIN CLASSIFICATION OF POSTERIOR HIP  
DISLOCATIONS

EPSTEIN CLASSIFICATION OF ANTERIOR HIP DISLOCATIONS

ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF HIP  
DISLOCATIONS

TREATMENT

CLOSED REDUCTION

OPEN REDUCTION

PROGNOSIS

COMPLICATIONS

**28. Femoral Head Fractures**

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

PIPKIN

ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF FEMORAL  
HEAD FRACTURES

TREATMENT

PIPKIN TYPE I

PIPKIN TYPE II

PIPKIN TYPE III

PIPKIN TYPE IV

FEMORAL HEAD FRACTURES ASSOCIATED WITH ANTERIOR  
DISLOCATIONS

COMPLICATIONS

**29. Femoral Neck Fractures**

EPIDEMIOLOGY

ANATOMY  
MECHANISM OF INJURY  
CLINICAL EVALUATION  
RADIOGRAPHIC EVALUATION  
CLASSIFICATION  
    ANATOMIC LOCATION  
    PAUWEL  
    GARDEN  
    ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF FEMORAL  
    NECK FRACTURES  
TREATMENT  
    FATIGUE/STRESS FRACTURES  
    IMPACTED/NONDISPLACED FRACTURES  
    DISPLACED FRACTURES  
    OPERATIVE TREATMENT PRINCIPLES  
COMPLICATIONS

**30. Intertrochanteric Fractures**

EPIDEMIOLOGY  
ANATOMY  
MECHANISM OF INJURY  
CLINICAL EVALUATION  
RADIOGRAPHIC EVALUATION  
CLASSIFICATION  
    EVANS  
    ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF  
    INTERTROCHANTERIC FRACTURES  
UNUSUAL FRACTURE PATTERNS  
    BASICERVICAL FRACTURES  
    REVERSE OBLIQUE FRACTURES  
TREATMENT  
    NONOPERATIVE  
    OPERATIVE  
        Timing of Surgery  
        Fixation Implants  
        Prosthetic Replacement  
        External Fixation  
        Special Considerations  
        Rehabilitation  
COMPLICATIONS  
    GREATER TROCHANTERIC FRACTURES  
    LESSER TROCHANTERIC FRACTURES

**31. Subtrochanteric Fractures**

EPIDEMIOLOGY  
ANATOMY  
    MECHANISM OF INJURY  
CLINICAL EVALUATION



RADIOGRAPHIC EVALUATION

CLASSIFICATION

RUSSELL-TAYLOR (HISTORICAL)

ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF  
SUBTROCHANTERIC FRACTURES

TREATMENT

NONOPERATIVE (HISTORICAL)

OPERATIVE

Implants

Bone Grafting

Open Subtrochanteric Fractures

COMPLICATIONS

LOSS OF FIXATION

NONUNION

MALUNION

32. Femoral Shaft Fractures

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

ASSOCIATED INJURIES

RADIOGRAPHIC EVALUATION

CLASSIFICATION

DESCRIPTIVE

WINQUIST AND HANSEN

ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF FEMORAL  
SHAFT FRACTURES

TREATMENT

NONOPERATIVE

Skeletal Traction

OPERATIVE

INTRAMEDULLARY NAILING

Antegrade Inserted Intramedullary Nailing

Retrograde Inserted Intramedullary Nailing

External Fixation

Plate Fixation

Femur Fracture in Multiply Injured Patient

Ipsilateral Fractures of the Proximal or Distal Femur

Open Femoral Shaft Fractures

REHABILITATION

COMPLICATIONS

33. Distal Femur Fractures

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

DESCRIPTIVE

NEER

ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF DISTAL FEMORAL FRACTURES

TREATMENT

NONOPERATIVE

OPERATIVE

Implants

Associated Vascular Injury

Supracondylar Fractures Above a Total Knee Replacement

Postoperative Management

COMPLICATIONS

34. Knee Dislocation (Femorotibial)

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

MODIFIED SCHENCK

DESCRIPTIVE

Utility of Anatomic Classification

TREATMENT

GENERAL TREATMENT CONSIDERATIONS

NONOPERATIVE

OPERATIVE

Treatment Recommendations of Specific Patterns

COMPLICATIONS

35. Patella and Extensor Mechanism Injuries

PATELLAR FRACTURES

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

Descriptive

Orthopaedic Trauma Association Classification of Patellar Fractures

TREATMENT

Nonoperative

Operative

COMPLICATIONS

PATELLA DISLOCATION

EPIDEMIOLOGY

- ANATOMY
- MECHANISM OF INJURY
- CLINICAL EVALUATION
- RADIOGRAPHIC EVALUATION
- CLASSIFICATION
- TREATMENT
  - Nonoperative
  - Operative
- COMPLICATIONS
- QUADRICEPS TENDON RUPTURE
- EPIDEMIOLOGY
- CLINICAL EVALUATION
- RADIOGRAPHIC EVALUATION
- TREATMENT
  - Nonoperative
  - Operative
- POSTOPERATIVE MANAGEMENT
- COMPLICATIONS
- PATELLA TENDON RUPTURE
- EPIDEMIOLOGY
- ANATOMY
- CLINICAL EVALUATION
- RADIOGRAPHIC EVALUATION
- CLASSIFICATION
- TREATMENT
  - Nonoperative
  - Operative
- COMPLICATIONS
- 36. Tibial Plateau Fractures**
- EPIDEMIOLOGY
- ANATOMY
- MECHANISM OF INJURY
- CLINICAL EVALUATION
- ASSOCIATED INJURIES
- RADIOGRAPHIC EVALUATION
- CLASSIFICATION
  - SCHATZKER
  - HOHL AND MOORE
  - ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF TIBIAL PLATEAU FRACTURES (TYPE 43)
- TREATMENT
  - NONOPERATIVE
  - OPERATIVE
- COMPLICATIONS
- 37. Tibia and Fibula Shaft Fractures**
- EPIDEMIOLOGY

ANATOMY  
MECHANISM OF INJURY  
CLINICAL EVALUATION  
RADIOGRAPHIC EVALUATION  
CLASSIFICATION  
    DESCRIPTIVE  
    ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF TIBIAL  
    FRACTURES  
    GUSTILO AND ANDERSON CLASSIFICATION OF OPEN FRACTURES (FINAL  
    GRADING DONE AFTER DEBRIDEMENT)  
    TSCHERNE CLASSIFICATION OF CLOSED FRACTURES

TREATMENT

NONOPERATIVE

    Acceptable Fracture Reduction  
    Time to Union  
    Tibia Stress Fracture  
    Fibula Shaft Fracture

OPERATIVE

    Intramedullary Nailing  
    Flexible Nails (Enders, Rush Rods)  
    External Fixation  
    Plates and Screws  
    Proximal Tibia Fractures  
    Distal Tibia Fractures  
    Tibia Fracture with an Intact Fibula  
    Fasciotomy

COMPLICATIONS

**38. Injuries about the Ankle**

ROTATIONAL ANKLE FRACTURES

    EPIDEMIOLOGY

    ANATOMY

    MECHANISM OF INJURY

    CLINICAL EVALUATION

    RADIOGRAPHIC EVALUATION

    CLASSIFICATION

        Lauge-Hansen (Rotational Ankle Fractures)  
        Orthopaedic Trauma Association Classification of Ankle Fractures  
        Fracture Variants

    TREATMENT

        Acute Care (Emergency Department)  
        Nonoperative  
        Operative

    COMPLICATIONS

PLAFOND (PILON) FRACTURES

    Epidemiology  
    Mechanism of Injury

- Clinical Evaluation
- Radiographic Evaluation
- Classification
- Orthopaedic Trauma Association Classification of Distal Tibia Fractures
- Treatment
- Complications

#### LATERAL ANKLE LIGAMENT INJURIES

- Mechanism of Injury
- Classification
- Clinical Evaluation
- Radiographic Evaluation
- Treatment

#### SYNDESMOSIS SPRAINS

- Classification
- Clinical Evaluation
- Radiographic Evaluation
- Treatment

#### ACHILLES TENDON RUPTURE

- Epidemiology
- Anatomy
- Clinical Evaluation
- Treatment

#### PERONEAL TENDON SUBLUXATION

- Clinical Evaluation
- Treatment

### 39. Calcaneus Fractures

#### EPIDEMIOLOGY

#### ANATOMY

#### MECHANISM OF INJURY

#### CLINICAL EVALUATION

##### ASSOCIATED INJURIES

#### RADIOGRAPHIC EVALUATION

#### CLASSIFICATION

##### EXTRA-ARTICULAR FRACTURES

##### INTRA-ARTICULAR FRACTURES

- Essex-Lopresti Classification

- Sanders Classification

#### ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF CALCANEAL FRACTURES

#### TREATMENT

##### NONOPERATIVE

##### OPERATIVE

##### SPECIFIC FRACTURES

- Extra-articular Fractures

- Intra-articular Fractures

#### COMPLICATION

40. Talus Fractures

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

ANATOMIC

HAWKINS CLASSIFICATION OF TALAR NECK FRACTURES

ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF TALAR FRACTURES

TREATMENT

FRACTURES OF THE TALAR NECK AND BODY

Nondisplaced Fractures (Hawkins Type I)

Displaced Fractures (Hawkins Types II to IV)

TALAR BODY FRACTURES

CLASSIFICATION

TREATMENT

LATERAL PROCESS FRACTURES

POSTERIOR PROCESS FRACTURES

TALAR HEAD FRACTURES

COMPLICATIONS

SUBTALAR DISLOCATION

TOTAL DISLOCATION OF THE TALUS

41. Fractures of the Midfoot and Forefoot

MIDTARSAL (CHOPART) JOINT

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

Medial Stress Injury

Longitudinal Stress Injury

Lateral Stress Injury

Plantar Stress Injury

TREATMENT

Nonoperative

Operative

COMPLICATIONS

TARSAL NAVICULAR

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION  
Orthopaedic Trauma Association Classification of Navicular Fractures  
Anatomic Classification

TREATMENT  
Nonoperative  
Operative

COMPLICATIONS

NAVICULAR DISLOCATION

CUBOID FRACTURES

EPIDEMIOLOGY  
ANATOMY  
MECHANISM OF INJURY  
CLINICAL EVALUATION  
RADIOGRAPHIC EVALUATION  
CLASSIFICATION  
Orthopaedic Trauma Association Classification

TREATMENT  
Nonoperative  
Operative

COMPLICATIONS

CUNEIFORM FRACTURES  
ORTHOPAEDIC TRAUMA ASSOCIATION CLASSIFICATION OF CUNEIFORM  
FRACTURES

TARSOMETATARSAL (LISFRANC) JOINT

EPIDEMIOLOGY  
ANATOMY  
MECHANISM OF INJURY  
CLINICAL EVALUATION  
RADIOGRAPHIC EVALUATION  
ASSOCIATED INJURIES  
CLASSIFICATION  
Quenu and Kuss  
Myerson

TREATMENT  
Nonoperative  
Operative  
Postoperative Management

COMPLICATIONS

FRACTURES OF THE FOREFOOT

METATARSALS  
Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Radiographic Evaluation  
Classification

Specific Metatarsal Injuries  
METATARSOPHALANGEAL JOINTS  
First Metatarsophalangeal Joint  
FRACTURES AND DISLOCATIONS OF THE LESSER  
METATARSOPHALANGEAL JOINTS  
Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Classification  
Treatment  
Complications  
SESAMOIDS  
Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Radiographic Evaluation  
Classification  
Treatment  
Complications  
PHALANGES AND INTERPHALANGEAL JOINTS  
Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Radiographic Evaluation  
Classification  
Treatment  
Complications  
Dislocation of the Interphalangeal Joint

## Part Five: PEDIATRIC FRACTURES AND DISLOCATIONS

### 42. Pediatric Orthopaedic Surgery: General Principles

OVERVIEW

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

SALTER-HARRIS AND PETERSON

TREATMENT

COMPLICATIONS

### 43. Pediatric Shoulder



## PROXIMAL HUMERUS FRACTURES

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

Salter-Harris

Neer-Horowitz Classification of Proximal Humeral Plate Fractures

TREATMENT

Newborns

Age 1 to 4 Years

Age 5 to 12 Years

Age 12 Years to Maturity

Acceptable Deformity

Open Treatment

PROGNOSIS

COMPLICATIONS

## CLAVICLE FRACTURES

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION

Descriptive

Allman

TREATMENT

Newborn to 2 Years

Age 2 to 12 Years

Age 12 Years to Maturity

Open Treatment

COMPLICATIONS

## ACROMIOCLAVICULAR JOINT INJURIES

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION

RADIOGRAPHIC EVALUATION

CLASSIFICATION (DAMERON AND ROCKWOOD)

TREATMENT

COMPLICATIONS

## SCAPULA FRACTURES

EPIDEMIOLOGY

ANATOMY

MECHANISM OF INJURY

CLINICAL EVALUATION  
RADIOGRAPHIC EVALUATION  
CLASSIFICATION  
    Classification by Location  
TREATMENT  
COMPLICATIONS  
GLENOHUMERAL DISLOCATIONS  
EPIDEMIOLOGY  
ANATOMY  
MECHANISM OF INJURY  
CLINICAL EVALUATION  
    Anterior Dislocation  
    Posterior Dislocation  
    Atraumatic Dislocation  
    Superior and Inferior (Luxatio Erecta) Dislocation  
RADIOGRAPHIC EVALUATION  
CLASSIFICATION  
TREATMENT  
COMPLICATIONS

44. Pediatric Elbow

EPIDEMIOLOGY  
ANATOMY  
MECHANISM OF INJURY  
CLINICAL EVALUATION  
RADIOGRAPHIC EVALUATION  
SPECIFIC FRACTURES  
    SUPRACONDYLAR HUMERUS FRACTURES  
        Epidemiology  
        Anatomy  
        Mechanism of Injury  
        Clinical Evaluation  
        Classification  
        Treatment  
        Complications  
    LATERAL CONDYLAR PHYSEAL FRACTURES  
        Epidemiology  
        Anatomy  
        Mechanism of Injury  
        Clinical Evaluation  
        Radiographic Evaluation  
        Treatment  
    MEDIAL CONDYLAR PHYSEAL FRACTURES  
        Epidemiology  
        Anatomy  
        Mechanism of Injury  
        Clinical Evaluation

Radiographic Evaluation  
Classification  
Treatment  
Complications

#### TRANSPHYSEAL FRACTURES

Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Radiographic Evaluation  
Classification  
Treatment  
Complications

#### MEDIAL EPICONDYLAR APOPHYSEAL FRACTURES

Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Radiographic Evaluation  
Classification  
Treatment  
Complications

#### LATERAL EPICONDYLAR APOPHYSEAL FRACTURES

Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Radiographic Evaluation  
Classification  
Treatment  
Complications

#### CAPITELLUM FRACTURES

Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Radiographic Evaluation  
Classification  
Treatment  
Complications

#### T-CONDYLAR FRACTURES

Epidemiology  
Anatomy  
Mechanism of Injury  
Clinical Evaluation  
Radiographic Evaluation