CONTENTS

Preface to the English edition (*K-G. Thorngren, H. Wingstrand*) XI Preface to the German edition (*H. Tscherne*) XIII Foreword to the German edition XV Foreword to the first Hungarian edition XVII

Chapter 1

Proximal femur fractures. Definition, epidemiology, anatomy, biomechanics (J. Manninger, G. Kazár †) 1

1.1 Introduction 1

1.2 Definition and frequency of hip fractures 2

1.2.1 Definition and basic concepts 2

1.2.2 Frequency of fractures – international and Hungarian data 4

1.2.3 Frequency of femoral neck fractures at the National Institute of

Traumatology (Budapest) between 1940 and 2002 5

- 1.3 Topographic and surgical anatomy 6
- 1.4 Correlation between osteoporosis, age and sex for hip fractures (I. Flóris) 15
- 1.5 Selected biomechanical characteristics of the proximal femur 18
- 1.6 The blood supply to the proximal femur 22

1.6.1 Anatomy of the arterial supply 22

- 1.6.2 Anatomy of the venous network 24
- 1.6.3 The capillary circulation (A. Réffy) 26

Chapter 2 Pathology of femoral neck fractures (J. Manninger, G. Kazár †) 29

2.1 General pathology 29

2.2 Stress- and spontaneous fractures of the femoral neck (L. Tasnádi) 33

2.3 The pathologic neck fracture 35

2.4 Circulatory disturbances 36

- 2.5 The intraosseous femoral head drainage (P. Füles †) 39
- 2.6 Types of femoral neck fractures 40
- 2.7 Grouping of fractures: Pauwels-, Garden- and AO-classification 44
- 2.8 The undisplaced neck fracture (Garden-I and -II) (P. Cserháti) 49

Chapter 3

Diagnostic investigations (J. Manninger, K. Fekete) 53

3.1 History and physical examination 53

3.1.1 Anamnesis 53

- 3.1.2 Inspection 53
- 3.1.3 Palpation 54
- 3.1.4 Functional examinations 54

3.2 Radiographic investigation. Special imaging procedures 54 3.2.1 Standard radiographic examination 54 3.2.1.1 Conventional radiographs in two planes (G. Springer t) 54 3.2.1.2 Supplementary radiographs 58 3.2.2 Special imaging procedures 59 3.2.2.1 Conventional tomography (G. Springer t) 59 3.2.2.2 MRI (Magnetic Resonance Imaging) (J. Kenéz) 593.2.2.3 Scintigraphy (bone scan) (Z. Kopcsányi) 63 3.2.2.4 SPECT (Single-Photon-Emission-Computertomography) (K. Karlinger) 64 3.2.2.5 Intraosseous venography 64 3.2.2.6 DSA (Digital Subtraction Angiography (J. Kenéz) 653.2.2.7 Sonography (E. Takács) 65 3.2.2.8 CT (Computertomography) (E. Takács) 68 3.2.2.9 DLR (Digital Luminescence Radiography (G. Springer †) 68 3.2.2.10 LDF (Laser Doppler Flowmetry (G. Springer †) 68 3.2.2.11 RSA (Roentgen-Stereophotogrammetric-Analysis) (P. Cserháti) 69 3.3 Examination of the circulation in the femoral head (intraosseous venography) (G. Kazár †) 70 3.3.1 Short description of the method 70 3.3.2 Indications for intraosseous venography 723.4 Diagnostic problems (recommendations how to avoid mistakes and errors) 75 **Chapter 4** Historical retrospection (G. Kazár †, J. Manninger) 85 4.1 History of the treatment of hip fractures 85 4.1.1 The beginnings 85 4.1.2 The development of internal fixation 854.1.3 The history of joint replacement 87 4.1.4 Beginnings of operative treatment of femoral neck fractures in Hungary 89 4.2 The stages of development of internal fixation for femoral neck fractures at the National Institute of Traumatology (Budapest) 89 4.2.1 Nailing of femoral neck fractures 89 4.2.2 Summary of the basic principles gained during 40 years of experience 98 4.2.3 Internal fixation with screws 99 4.2.4 Percutaneous insertion of two screws 101 **Chapter 5** Biomechanical aspects of cannulated screw fixation. Experimental investigations and developments (J. Manninger, I. Bagi, I. Flóris, T. Laczkó, P. Soltav, P. Cserháti, G. Vámos, I. Kádas) 1055.1 The importance of three-point buttressing 105 5.2 Reinforcement of the first point of buttressing – improvement of the purchase in the femoral head 107

5.2.1 Problems of stability concerning the femoral head 107 5.2.2 Modifications of the screw threads to improve stability 107 5.2.3 Comparative avulsion test of femoral neck screws possessing various thread qualities and thread diameter 108 5.2.4 Testing of avulsion force of neck screws enforced by bone cement 111 5.2.5 Assessment of results 111 5.2.6 Investigations into the rotational stability of flanged screws 112 5.2.7 Improvement of stability with three screws 113 5.2.8 Improvement of stabilization - clinical examples 114 5.3 Reinforcement of the second buttressing point: Adam's arch and calcar femorale 119 5.3.1 Problems of stability at the second buttressing point 119 5.3.2 Improvement of the stability of internal fixation with a 2 mm threehole plate attached to both screw end 122 5.3.3 Improvement of stability of internal fixation of Pauwels-III fractures in combining screws of different thread lengths 123 5.3.4 Angle-stable Dynamic Collo-Diaphyseal (DCD) plates for "absent" Adam's arch 125 5.4 Reinforcement of the third buttressing point – lateral cortex 130 5.4.1 Stability problems at the third buttressing point – varus and rotational movements as well as loss of reduction 130 5.4.2 Thickening of the lateral cortex after screw fixation without a 2 mm twohole plate 131 5.4.3 Investigations testing the effectiveness of a 2 mm two-hole plate 132 5.4.4 Proper attachment of the 2 mm two-hole plate 133 5.4.5 Clinical examples of stabilization with a 2 mm two-hole plate 134 5.5 Importance of the loss of reduction in rotation and possibilities to avoid it 137 5.6 Settling of the fracture leading to shortening of the femoral neck 1385.7 Recent improvements and concepts for the future 142 Chapter 6 Justification for early surgery (K. Fekete, G. Kazár †, J. Manninger) 149 6.1 Timing for internal fixation of hip fractures 149 6.2 The progress of emergency surgery in Hungary 1496.3 Determination of the optimal moment of surgery – summary of investigations performed in Budapest 156 6.4 Guaranteeing the prerequisites for an immediate surgery 157 6.5 Present treatment methods at the National Institute of Traumatology (Budapest) 160 6.6 General condition and co-morbidity of the elderly accident victim 160

Chapter 7

Reduction of the fracture (J. Manninger, T. Salacz, K. Fekete) 163

7.1 Introduction 163

7.2 Closed reduction of displaced neck fractures 164

7.3 Open reduction of a displaced neck fracture 167

7.4 Reduction of a Garden-I fracture impacted in hypervalgus (P. Cserháti) 169

7.5 Frequent errors of reduction 173

7.6 Guidelines for the assessment of reduction (Z. Detre, P. Cserháti) 173

Chapter 8

Internal fixation (K. Fekete, J. Manninger, T. Salacz, U. Bosch) 181

8.1 Preparation for surgery 181

8.1.1 Preparation for immediate internal fixation (A. Eckhardt) 181

8.1.2 Internal fixation done under local anesthesia 181

8.1.3 Preparations for delayed internal fixation, role of skeletal traction 182

8.1.4 Algorithm for the treatment of neck fractures (G. Kazár †, P. Cserháti) 185

8.2 Implants and instruments for cannulated screw fixation of neck fractures 185

8.2.1 Implants for cannulated screw fixation 185

8.2.2 Instruments for cannulated screw fixation 189

8.3 Technique of percutaneous screw fixation of neck fractures 191

8.3.1 Introduction 191

8.3.2 Technique of percutaneous screw fixation 191

8.3.2.1 Positioning, disinfection, sterile draping 191

8.3.2.2 Determination of the site of skin incision and placement of drill channels 192

8.3.2.3 Steps of the surgical technique 194

- 8.3.3 Frequent technical errors and ways to avoid them 200
- 8.4 Guidelines for the assessment of internal fixation (J. Manninger, Z. Detre,

P. Cserháti) 201

- 8.5 Internal screw fixation with exposure of the femur 208
- 8.6 Technique to increase the stability of internal fixation 210

8.6.1 Introduction 210

- 8.6.2 Screws with a 9.5 mm thread diameter (J. Baktai) 210
- 8.6.3 Flanged screw (T. Laczkó, I. Flóris) 210
- 8.6.4 Internal fixation with three cannulated screws (T. Laczkó) 210

8.6.5 Attachment of two screws to 2 mm plates 211

8.6.6 Simple and double DCD plates, satellite plates (T. Laczkó, L. Tasnádi) 211

Chapter 9

Treatment of undisplaced and atypical femoral neck fractures (J. Manninger, P. Cserháti, W. Stock) 213

9.1 Treatment of undisplaced femoral neck fractures (Garden-I and -II) 213

- 9.1.1 Introduction 213
- 9.1.2 Treatment of undisplaced femoral neck fractures at the National Institute of Traumatology (Budapest). 213
- 9.1.3 Results of internal fixation of undisplaced femoral neck fractures 215
- 9.2 Femoral neck fractures in young adults (20-50 years-old) 217
- 9.3 Femoral neck fractures in children and adolescents (E. Hargitai, W. Stock) 219
- 9.4 Treatment of stress fractures of the femoral neck (L. Tasnádi) 228
- 9.5 Treatment of pathologic femoral neck fractures 232
 - 9.5.1 Treatment of pathologic neck fractures due to bone cysts 232
 - 9.5.2 Compression fracture in osteomalacia 235
 - 9.5.3 Femoral neck fractures in osteopetrosis (Albers-Schönberg disease, marble bones) (K. Fekete) 235
 - 9.5.4 Femoral neck fracture in osteosclerosis 237
 - 9.5.5 Femoral neck fractures after poliomyelitis 239

9.5.6 Femoral neck fractures in osteogenesis imperfecta (E. Hargitai) 2409.5.7 Femoral neck fractures due to primary tumors or metastases (J. Baktai) 241Chapter 10 Postoperative treatment, early complications (K. Fekete, J. Manninger, P. Cserháti) 24510.1 Early postoperative treatment and problems encountered during this period (A. Eckhardt) 245 10.1.1 Postoperative regimen 245 10.1.2 Early systemic complications; their prevention and treatment 245 10.1.2.1 Cardiovascular complications 245 10.1.2.2 Neurologic complications 246 10.1.2.3 Additional systemic complications 24610.2 Early complications of the surgical wound 247 10.2.1 Hematoma 247 10.2.1.1 Clinical and diagnostic aspects of postoperative hematomas 247 10.2.1.2 Treatment of a postoperative hematoma 24910.2.2 Wound infection 249 10.2.2.1 Clinical presentation and diagnosis of postoperative soft tissue and joint infection 249 10.2.2.2 Treatment of postoperative wound infection 250 10.3 Mobilization, follow-up care (G. Kazár †, T. Laczkó) 251 10.4 Local mechanical complications after internal fixation with cannulated screws and their treatment 252 10.4.1 Loss of reduction 252 10.4.2 Migration of the implant 253 10.4.3 Femur fractures after internal fixation 257 Chapter 11 **Results of treatment** (G. Kazár †. P. Cserháti, U. Bosch, G. Árva, J. Baktai, I. Bárdos, I. Czermann, K. Fekete, I. Flóris, T. Laczkó, J. Manninger, A. Melly, M. Sashegyi, Z. Szelényi, I. Varga, Z. Vendégh, G. Végh) 259 11.1 Introduction 259 11.2 Comparison between Smith-Petersen nailing and cannulated screw fixation 259 11.3 Score results of the analysis of reduction and internal fixation 263 11.4 Analysis of the causes for loss of reduction 264 11.4.1 Importance of proper reduction and internal fixation 264 11.4.2 The influence of fracture morphology on the occurrence of loss of reduction 267 11.4.2.1 Garden classification 267 11.4.2.2 Pauwels classification 267 11.4.2.3 State of fracture surfaces 268 11.4.3 Correlation between age (osteoporosis) and loss of reduction 26811.4.4 Experiences with the lateral reinforcement 269 11.5 Cannulated screw fixation 1993–94 in comparison with 1997–98 271 11.6 Treatment of femoral neck fractures – internal fixation versus joint replacement 274

Chapter 12 Appendix 279

- 12.1 Definition of terms particular to the subject of internal fixation of femoral neck fractures 279
- 12.2 Members in charge of the research team "Femoral Neck Fractures" at the National Institute of Traumatology (Budapest) 283
- 12.3 The foreign teachers, councilors and supporters 283

References 287 Subject Index 301 List of Contributors 309