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HIP FRACTURES IN ADULTS

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REVIEW ARTICLE

Classfication of Hip Fractures: Neck of Femur, Intertrochanteric, and Subtrochanteric Fractures

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Abstract

Fractures around the hip are common injuries seen in orthopedic practice, particularly in the elderly population. These fractures include femoral neck, intertrochanteric, and subtrochanteric fractures. These fractures are often associated with significant morbidity, mortality, and socioeconomic burden due to prolonged immobilization and loss of independence in physiologically and biologically compromised elderly. Timely surgical management is key to restore mobility, reduce complications, and improve functional outcomes. However, surgical management of these fracture is often challenging and require proper understanding of fracture morphology and characteristics. Classifying these fractures not only helps in better understanding of fracture characteristics but also beneficial in record keeping, communication, and understanding prognosis and patient counselling. This article discusses several classification systems available for neck of femur, intertrochanteric and subtrochanteric fractures. In addition, comparative overview of various classification systems is also presented.

KEYWORDS

Hip Fractures; Femoral Neck Fractures; Femoral Fractures; Fracture Fixation, Internal; Biomechanics; Tomography, X-Ray Computed; Aged; Osteoporosis

Introduction

Fractures around the hip are common injuries seen in orthopedic practice, particularly in the elderly population.[1] These fractures include femoral neck, intertrochanteric, and subtrochanteric fractures.[2] These fractures are often associated with significant morbidity, mortality, and socioeconomic burden due to prolonged immobilization and loss of independence in physiologically and biologically compromised elderly.[3] Timely surgical management is key to restore mobility, reduce complications, and improve functional outcomes.[4] However, surgical management of these fracture is often challenging and require proper understanding of fracture morphology and characteristics.[4,5]

Improper choice of surgical technique and devices often lead to several complications, such as non-union, implant failure, and prolonged recumbency related complications.[6,7] The choice of fixation depends heavily on the fracture stability which can be done using various classification systems.[8] Classifying these fractures not only helps in better understanding of fracture characteristics but also beneficial in record keeping, communication, and understanding prognosis and patient counselling.[2,9,10]

Neck of femur fracture

Femoral neck fractures in the elderly population are usually fragility fractures due to osteoporosis, whereas in younger patients they are due to high-energy trauma and road accidents. These fractures are intracapsular, and thus carry a unique risk of avascular necrosis (AVN) and nonunion due to disruption of the femoral head blood supply. Rapid assessment and appropriate classification guide decisions regarding fixation versus arthroplasty and influence predicted outcomes. Multiple classification schemes have been developed for femoral neck fractures over the past century. An ideal fracture classification system should possess simplicity, reproducibility, interobserver reliability, and prognostic significance. While no single system fully meets these criteria, several remain widely used in clinical decision-making.

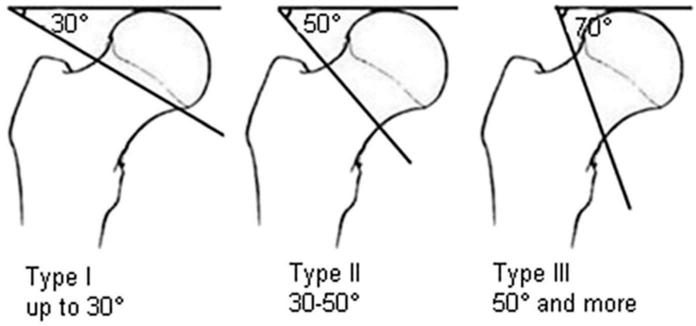

Figure 2 Pauwels Classification. Picture Taken from Shen et al. (2016): An Update on the Pauwels Classification[14]

The anatomical classification is based on the location of fracture. Subcapital fractures are just below the femoral head and carry a higher risk of AVN. Transcervical fractures are around the mid-neck region and are common. Basicervical fractures at the base of the neck have better healing potential and behave more like extracapsular fractures. (Figure 1)

The femoral neck is an intracapsular structure surrounded by the hip joint capsule. The most relevant anatomical considerations include vascular supply, inclination angle and trabecular architecture. The medial femoral circumflex artery provides the primary blood supply to the femoral head. The neck-shaft angle (~125°) significantly affects fracture stability. The compression and tensile trabecular lines dictate biomechanical patterns of fracture. Femoral neck fractures were initially classified by Sir Astley Cooper in 1823 into two categories: intra-capsular and extra-capsular, with prognostic implications.[11]Another classification, the Pauwels classification, was first proposed in 1935.[12] It is a biomechanical system dividing femoral neck fractures on the basis of the inclination of the fracture line relative to the horizontal in AP radiograph. (Figure 2) Bartonicek gave the definitive interpretation and angle definitions for each category.[13] With increasing angle, forces acting on the fracture line shift from compressive to shearing, which increases the risks of displacement, non-union after reduction, and fixation failure.[12] This classification system is biomechanically sound and predicts risk of nonunion. The limitations are variability in measurement, and less commonly used in isolation. (Table 1)

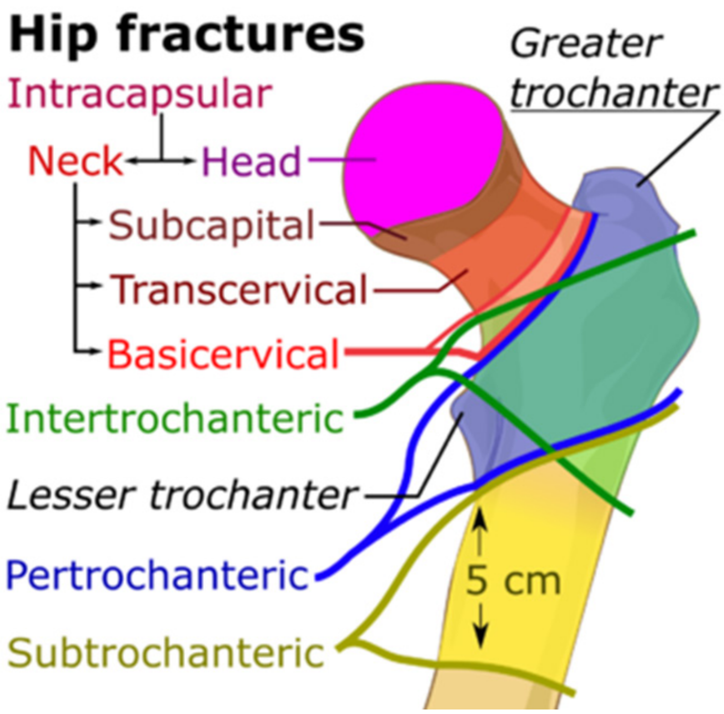

Figure 1 Anatomic classification of proximal femur

Robert Symon Garden, a British orthopaedic surgeon, introduced a more comprehensive classification system in 1961, based on the degree of displacement, the completeness of the fracture, and the alignment of the trabeculae in the head and neck of the femur on the basis of AP radiograph.[15] Garden's research, which analyzed 80 patients, categorized femoral neck fractures into four types (I-IV). (Figure 3) He tracked the outcomes for at least 12 months post-surgery. Fractures classified as class I and II achieved 100% union rates, while class III and IV had union rates of 92% and 58%, respectively. On the basis of anteroposterior (AP) radiographs of the hip, Garden's classification distinguishes fractures as incomplete and valgus impacted, complete and nondisplaced, complete and partially displaced, and complete and fully displaced.[16–18] This classification is simple and widely used. It guides management algorithms of internal fixation versus arthroplasty. The

Table 1. Pauwel's classification of NOF fractures

Pauwel's Type	Inclination Angle	Biomechanic	Risk
I	<30°	Compression-dominant forces	Low shear, stable
II	30 - 50°	Mixed compression and shear	Moderate instability
III	>50°	Shear-dominant forces	Unstable, non-union risk

Table 2. Garden classification of NOF fractures

Garden Type	Radiographic features	Clinical Significance
I	Incomplete, valgus impacted	Stable, low risk of AVN
II	Complete, nondisplaced	Relatively stable, preserved blood supply
III	Complete, partially displaced; trabeculae misaligned	Unstable, moderate risk of AVN
IV	Displaced; head and neck trabeculae mismatch	Highest risk of AVN and nonunion

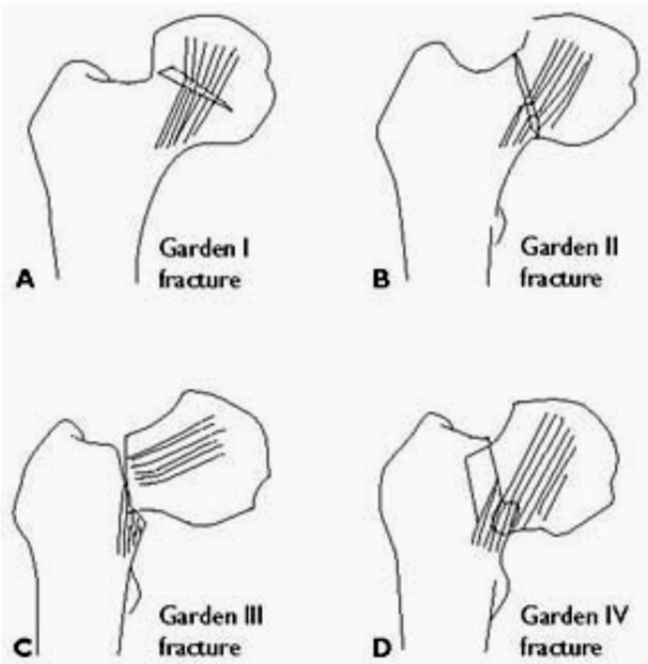

Figure 3 Garden Classification. Picture Taken from Jochen Friedrich's Doctoral Dissertation[19]

limitations are moderate interobserver reliability and the difference in subjective assessment of displacement. (Table 2)

The standard (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) AO/OTA classification (https://www.aofoundation.org/trauma/clinical-library-and-tools/journals-and-publications/classification) provides a universal language for trauma classification, naming femoral neck fractures as 31-B.[20] It is further classified on the basis of displacement, impaction and comminution. The advantage of AO/OTA classification is being comprehensive and widely accepted internationally. It is better reproducible than garden or Pauwels. The complexity reduces everyday clinical use and it lacks prognostic specificity.

Amongst all the classification system, the AO/OTA has the best reproducibility but the garden is most clinically influential. The clinical implications of fracture classification in neck of femur are decision making in the treatment. Garden I–II are treated with internal fixation with cannulated screws, dynamic hip screw (DHS), or the more recent femoral neck system (FNS). Garden III–IV in elderly are treated with hemiarthroplasty or total hip arthroplasty. The Pauwels III fractures with high shear forces may be treated with valgus intertrochanteric osteotomy or fixed-angle devices. AVN is highest in Garden III–IV and subcapital fractures. The degree of displacement correlates strongly with development of AVN.

Intertrochanteric fracture

Intertrochanteric (IT) fractures are the most common fractures seen in elderly osteoporotic patients, usually due to trivial ground level fall. Most classifications are based on stability, comminution, reduction, posteromdeial wall and lateral wall integrity, that decide the choice of fixation. Few classifications have focused on stability and anatomical pattern.[21] Early classification schemes were developed based on

Table 3. Comparison of the various classification systems for NOF fractures

System	Basis	Types	Strengths	Weaknesses
Garden	Displacement	I-IV	Simple, Prognostic	Moderate reliability
Pauwels	Biomechanics	I-III	Predicts nonunion	Angle measurement not consistent
AO/ OTA	Anatomic + Morphologic	B1-B3	Comprehensive	Complex
Anatomic	Location	Subcapital, Transcervical, Basicervical	Easy	Low prognostic value

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plain radiographs and anatomical observations.

The Evans classification described in 1949 is one of the earliest systems for IT fractures. It categorizes fracture morphology based on fracture line direction and displacement.[21] Type I Fracture line extends upward and outward from the lesser trochanter, or they are inherently stable or stable after reduction and labelled as stable. Type II Fracture line extends downward and outward and is labelled unstable shifting medially or the reverse oblique fracture. Evans classification is simple and correlates with stability, but does not include all patterns, and has inconsistent inter-observer reliability. Jensen and Michaelsen modified Evans classification to include five subtypes based on displacement, number of fragments, and medial/ posterior support.[22] (Figure 4) The aim was to better differentiate between stable and unstable patterns. Stability correlates with the number of fragments and the presence of medial comminution. This classification relies on plain radiographs to better describe the fracture complexity, but still shows only moderate reproducibility. Boyd and Griffin's classification focuses on treatment recommendations and recognizes four types of fractures, emphasizing comminution and reverse obliquity patterns.[23] (Figure 5) The advantage of this classification system is its usefulness for surgical planning, but it lacks subtype descriptions. The AO/OTA classification system (https://www.aofoundation.org/trauma/clinical-library-and-tools/journals-and-publications/classification) is widely accepted and extensively used in research.[20] It classifies proximal femur fractures under code 31A, with subdivisions based on complexity. AO/OTA classifications have a broad framework and allow for consistency in multicenter studies. However complex subgroups may show lower reliability among observers. As the system is two-dimensional based on radiographs it may fail to describe detailed fracture fragment morphology seen on CT.

In general, classic systems like Evans, Jensen, and AO/OTA show fair-to-moderate reliability, while modern approaches based on 3-D imaging offer better reproducibility. Newer classification approaches based on 3D- CT offer detailed view of fracture morphology. Tang classification was developed using artificial intelligence and 3-D imaging. Tang system focuses on clear identification of fragment morphology and has shown substantial inter-observer reliability outperforming traditional systems, and enabling a more precise anatomical description, which again can guide implant selection.[25] It has higher reliability as it delineates better fragment detail than 2-D systems. Japanese 3-D CT based classification possess high reliability comparable to or slightly better than the Tang classification with

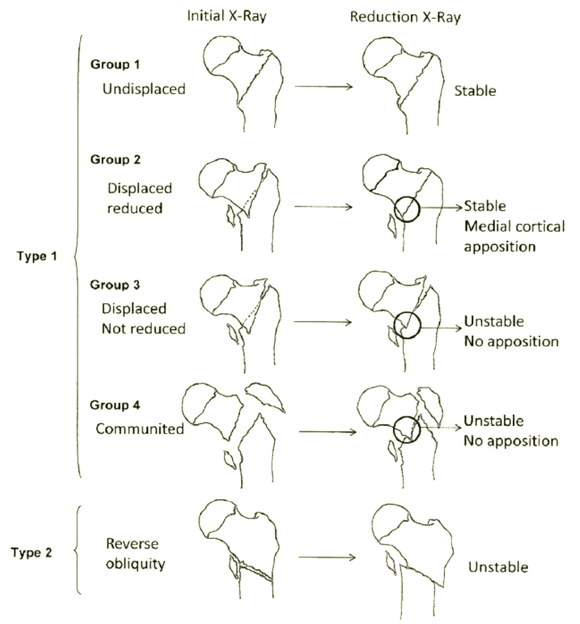

Figure 4 Evan's Classification. (Picture Adapted from Mokawem et al. study: The Management of Per trochanteric Fracture of the hip[24]

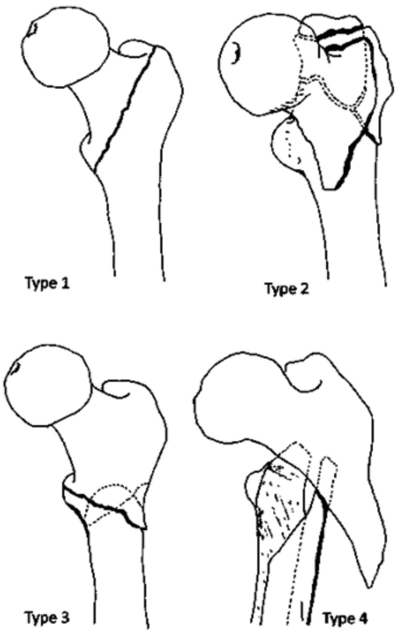

Figure 5 Boyd and Griffin's Classification. Type 1: Fractures extend along the intertrochanteric line (2 part); Type 2: The main fracture is along the intertrochanteric line with posteromedial comminution; Type 3 fractures have a subtrochanteric component involving the cortex at or just distal to the lesser trochanter, Type 4: fractures involve the intertrochanteric and subtrochanteric regions (Picture Adapted from Mokawem et al. study: The Management of Per trochanteric Fracture of the hip[24]

substantial observer agreement.[26] But again global validations is due and requires availability of CT and 3D reconstruction images.

In a recent multicenter study, the comprehensive classification demonstrated higher inter-observer and intra-observer reliability compared to Evans, AO/OTA classification. This system integrates features from traditional and new methodologies to provide a detailed description with improved reproducibility.[27] Recent research exploring artificial intelligence (AI) and deep learning to assist fracture classification from imaging reveal greater consistency and efficiency. However, such classifications are not yet standardized for clinical use. (Table 4)

Subtrochanteric fracture

Typical subtrochanteric fractures (ST) are seen commonly in elderly with osteoporotic bone and in younger adults with high velocity trauma. Atypical ST fractures occur in patient treated with bisphosphonates and are much less common. In spite of the many classification systems in use, there is lack of agreement on the definition of the subtrochanteric zone itself, and few show limited reliability and limited predictive value for outcome.[28] The widely accepted subtrochanteric zone is the area extending distally from the inferior border of the lesser Trochanter (LT) to a point approximately 5 cm below, distally.[23,29,30]

Fielding classification is one of the earliest classifications and is based on anatomical locations based on their distance below the LT.[30] Type I is at the level of LT. Type II is within 2.5 cm below LT. Type III is 2-5-5cm below LT. (Figure 6) This classification is simple but does not describe fracture morphology, comminution, or stability. Its clinical utility is limited as it lacks prognostic values. The Seinsheimer classification (1978) is popular and provides detailed morphology of subtrochanteric fractures.[31] It emphasizes on the number of fragments and fracture pattern. Type I is undisplaced, type II is two-part fracture with type IIA, B and C further division, where A is transverse, B is spiral with LT attached with proximal and C is spiral with LT attached with distal fragment respectively. Type III is three-part fractures with type IIIA indicating LT as third fragment and IIIB with butterfly fragment as third fragment. Type IV is comminuted fractures

Table 4. Summary of the various classification systems for Intertrochanteric Fracture

Classification	Basis	Description	Advantages	Limitations
Evans	X-ray	Stable vs. unstable types	Simple, easy	Moderate reproducibility
Jensen	X-ray	5 subtypes	Better fragment detail	Moderate reproducibility
Boyd-Griffin	X-ray	4 types	Useful for surgical guidance	Few subtypes, variable reliability
AO/OTA 31A	X-ray	A1–A3 with subgroups	Widely used in research	Various subgroups, low reliability
Tang	3-D CT	Fragment-based	High reliability	Requires CT
Japanese	3-D CT	Fragment-based	High reliability	Needs global validation
Comprehensive	CT/3D integration	Multidimensional	Higher reliability	Complex, no global validation

AO/OTA Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association; *CT* Computed Tomography

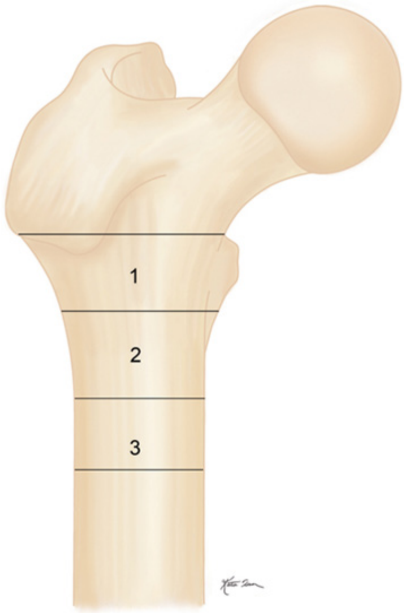

Figure 6 Fielding Classification. Type 1: fractures (most common) occur at the level of the lesser trochanter; Type 2: up to 2.5 cm below the lesser trochanter; Type 3: Between 2.5 and 5 cm below the lesser trochanter. (https://radiologykey.com/)

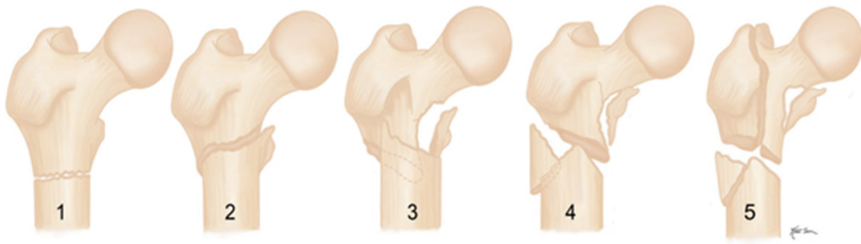

Figure 7 Seinsheimer Classification. Type 1: Nondisplaced; Type 2: Two-part: transverse, oblique, or spiral fracture with or without extension into the lesser trochanter; Type 3: Three-part: oblique or spiral fracture with either detached lesser trochanter or butterfly fragment posterior; Type 4: Oblique or spiral fracture with detached lesser trochanter and butterfly fragment posteriorly; Type 5: Subtrochanteric and intertrochanteric fractures. (https://radiologykey.com/)

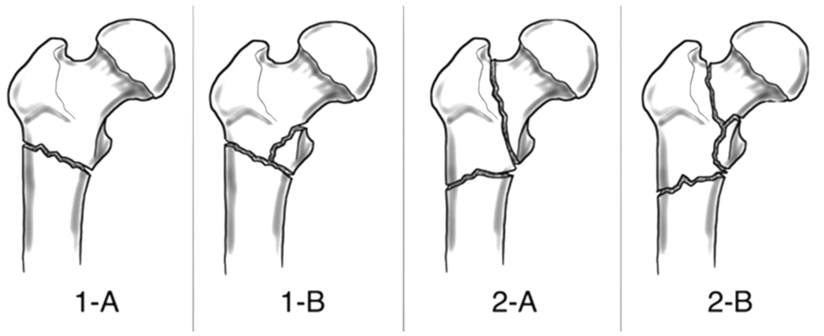

Figure 8 Russel Taylor Classification. Type 1A: fractures that do not involve the piriformis fossa. Type 1B: fractures do not involve the piriformis fossa but do involve the lesser trochanter. Type 2A: fractures through the piriformis fossa but not involving the lesser trochanter; Type 2B:fractures involving both the lesser trochanter and piriformis fossa. (Picture Adapted from Rizkella et al. (2019) study on "Classifications in Brief: The Russell-Taylor Classification of Subtrochanteric Hip Fracture" reprinted with permission from Guyver et al. (2014) study on "Is there any purpose in classifying subtrochanteric fractures? The reproducibility of four classification systems"[33,34])

with more than 4 pieces. Type V is subtrochnateric fracture extending into greater trochanter. (Figure 7) The Russell–Taylor classification highlights the involvement of trochanteric fossa and lesser trochanter.[32] Type I is fracture not extending into trochanteric fossa. It is further subdivided. IA is without LT extension and B is with LT extension. Type II is fracture extending into trochanteric fossa. Type II is further subdivided into IIA which is intact LT and IIB as comminuted LT. (Figure 8) Russell-Taylor classification is commonly used and it describes the difficulty in reduction and fixation related to the involvement of trochanter.[33]

The AO/OTA (Orthopaedic Trauma Association) system (https://www.aofoundation.org/trauma/clinical-library-and-tools/journals-and-publications/classification) is a broad, alphanumeric scheme that includes subtrochanteric fractures within the femoral diaphyseal region 32.[20] 32A being simple fracture, 32B wedge fracture and 32C complex fracture which are again subclassified respectively. Although widely known for long bone fractures in general, this system was not specifically designed for subtrochanteric fractures and tends to mix them with other diaphyseal patterns. As a result, it shows poor inter-observer reliability when used for subtrochanteric fractures alone.

Conclusion

Femoral neck fracture classification remains essential in describing treatment strategies and anticipating complications. The Garden classification continues to dominate clinical practice due to its simplicity and prognostic utility, while the Pauwels classification provides biomechanical insights. The AO/OTA classification offers a standardized international framework with improved reproducibility. Advances in imaging and computational models may describe the precision and prognostic power of classification systems. A combined multimodal approach integrating radiographic, biomechanical, and patient-specific factors is likely to define the future of femoral neck fracture classification and management.

Classification of intertrochanteric fractures is essential for clinical decision making and research. Traditional systems such as Evans, Jensen, Boyd-Griffin, and AO/OTA remain useful, but they have limitations in reliability, particularly with complex fracture patterns. Emerging 3-D CT-based classifications and comprehensive schemes demonstrate

Table 5. Overview of the various classification systems for subtrochanteric fractures

System	Basis	Details	Treatment implication
Fielding	Location	No morphology, only distance	
Seinsheimer	Fragment count and pattern of fracture	Morphology, fragment involvement	Nail choice, open reduction or circlage
Russell–Taylor	Relation to trochanteric fossa	Extension, trochanter involvement	Technical challenge, assisted reduction and supplemental implant like plates
AO/OTA	Long bone coding system	Morphology but broad	

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improved reproducibility and may guide treatment planning in the future. Subtrochanteric femoral fractures represent a difficult clinical entity with complex biomechanics and varied fracture patterns. Numerous classification schemes have been proposed from location-based systems like Fielding to pattern-focused systems like Seinsheimer and anatomical systems like Russell–Taylor. Newer classifications should take into account the fracture morphology, biomechanics, stability, as well as patient factors like bone quality and age. The use of CT and 3D imaging to create integrated models could better guide both operative strategy and outcome prediction, but remain in the early stages of development.

Conflict of Interest

None

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