The 'Unsolved' Fracture Neck of Femur – A Comprehensive Review

Sandeep Vijayan¹, Nikhil Hegde¹, Mahesh Suresh Kulkarni¹, Monappa Naik Aroor¹,
Vishweshwar Bhat¹, Sharath K Rao¹

Abstract

Introduction: Fractures involving the neck of the femur constitute a small proportion of total fractures in the body. Though these fractures mainly occur in the elderly population, their occurrence in youngsters due to high-velocity trauma is not uncommon. These fractures are commonly termed the 'unsolved fractures' as the outcome of these fractures are highly variable. The peculiar anatomy and precarious blood supply to the proximal femur and intracapsular location create an unfavourable biological environment for fracture union. The lack of prospective clinical trials which have evaluated the ideal surgical timing, technique and construct of the implant further adds to the confusion.

Discussion: The aim of this review was to go through the recent relevant literature on the management of femoral neck fractures to find out the answers to the debated questions and to summarize the current diagnostic and management approaches to a patient with a suspected fracture neck of the femur.

Conclusion: Knowing the patient and fracture related factors which influence the outcome are extremely important to achieve the goal of early uncomplicated fracture healing. This would help the surgeon in the thoughtful selection of the operative intervention for each patient on an individual basis and facilitate a thorough discussion between the surgeon and the patient which is vital in decision making.

Keywords: Closed reduction, Hemiarthroplasty, Hip fractures, Intracapsular, Neck of Femur, Pauwel

Introduction

Intracapsular fractures of the neck of femur (FNOF) in adults was termed as 'the unsolved fracture' by Dickson [1, 2]. It was the French surgeon Ambrose Pare in 1564 who gave the first description of hip fractures. FNOF account for approximately 54% of hip fractures and 3.58% of total fractures in the body [3]. The incidence of hip fractures is likely to rise from the current 4 million to 6.3 million by 2050 [3].

The outcome of these fractures is highly variable and are determined by anatomical, biological and mechanical factors which are not completely under the control of the treating surgeon. The anatomy of the proximal femur is peculiar due to its precarious blood supply [4–6]. Biological parameters include lack of cambium layer in the periosteum of the femoral neck and washing away off the fracture hematoma by the intracapsular synovial fluid, while mechanical parameters

include the inclination of the fracture line, comminution of the posterior cortex, precision of fracture reduction and stability of fixation [5]. To add to this there are conflicting evidence in the literature about the timing of surgery and ideal treatment of these fractures. The mortality rate following fracture neck of femur (FNOF) in elderly patients is relatively high and is reported to be 8.4 to 36% within the first year. The reoperation rate is also reported to range from 10.0 to 48.8%. About 2–6% of cases with femur shaft fracture has ipsilateral neck fracture and is likely to be missed if not looked for [4, 7].

Femoral Head Vascularity

Vascularity to the head of the femur is mainly by the medial femoral circumflex branch of the profunda femoris artery which forms the extra-capsular anastomosis. From this, the lateral epiphyseal artery complex arises to course along the femoral neck and supply the superolateral part of the head of the femur. The infero-anterior portion of the head of the femur is supplied by the inferior metaphyseal artery which arises from the ascending branch of the lateral femoral circumflex artery. The Obturator artery supplies the foveal area via the artery of ligamentum teres [4, 6–8].

¹Department of Orthopaedics, Kasturba Medical College Manipal, Manipal Academy of Higher Education (MAHE), Manipal, Udupi, Karnataka, India.

Address of Correspondence :

Dr. Mahesh Suresh Kulkarni,
Department of Orthopaedics, Kasturba Medical College Manipal, Manipal Academy of Higher Education (MAHE), Manipal, Udupi, Karnataka, India.
E-mail: maheshskulkarnibmc@gmail.com

Submitted: 1/6/2021; Reviewed: 29/6/2021; Accepted: 18/7/2021; Published: 10/8/ 2021

Journal of Karnataka Orthopaedic Association | Available on www.jkoaonline.com | DOI:10.13107/jkoa.2021.v09i02.038

This is an Open Access journal and articles are distributed under the terms of the Creative Commons Attribution Non-Commercial-Share Alike 4.0 License (<http://creativecommons.org/licenses/by-nc-sa/4.0>) which allows others to remix, tweak, and build upon the work non-commercially as long as appropriate credit is given and the new creation are licensed under the identical terms.

Risk, Incidence and mode of injury in FNOF

The risk for FNOF rises with excessive hip axis and femoral neck length and smaller cross-sectional area of the neck [4, 9, 10]. Bone mineral density, bone geometry and cortical thickness at the femoral neck are the most reliable predictors of FNOF and is easily obtained by assessment with dual energy X-ray absorptiometry scan (DEXA) and quantitative computed tomography of the head and neck of the femur.

Intracapsular FNOF occurs in a bimodal distribution, peaking in the elderly patients in their eighties [2, 4, 6, 9, 11, 12]. In young adults they are less common (2-11%) and usually occur due to high-energy trauma. In youngsters with early age-related bone fragility, alcoholism and predisposing diseases, even comparatively low energy trauma can lead to these fractures [10].

Though in the majority of the cases, old or young, trauma is an antecedent factor in causing the fracture, it can also occur secondary to pathological lesions or repetitive stress at the femoral neck. A sideways fall requires considerably lesser force to induce a cervico-trochanteric or trochanteric fracture than compared to vertical impact loading [10, 12]. Characteristic differences are noted in the bony and vascular anatomy, mechanism of injury, fracture pattern, accompanying injuries and goals of treatment among the physiologically active, young patients and elderly frail patients [5, 6]. Understanding these differences facilitates proper treatment.

Decision Making in Treatment

Decision making in the treatment of FNOF depends on the physiological age, comorbidities, mobility status before the fracture, bone quality, the configuration of the fracture, associated injuries and pre-existing degenerative arthritis of the joint.

Establishing the physiological age of patients is extremely important [2]. This in turn is determined by patients activity level before the fall, co-morbidities, cognitive level, living conditions and quality of the bone. In general, patients over 80 years are considered as elderly and those younger than 60 years is considered as 'young' [7]. Hemiarthroplasty (HA) is usually reserved for patients above 80 years, while internal fixation and salvage of the native femoral head is considered ideal for patients below 60 years. Management of patients in the 60 to 80-year age group with displaced FNOF still remain in a grey zone [7]. They are further deemed to be 'young or old' based on their cognition and activity level. Those who are active with high functional demand, good bone quality, and minimal medical comorbidities are considered as 'young'. Whereas patients with low functional demand or using a walking aid or having chronic illnesses with poor bone quality are regarded as 'elderly/old' and managed accordingly [7].

Radiological Evaluation

Anteroposterior view of the pelvis including both hip joints with the limb in 15° of internal rotation, cross-table lateral view of the involved hip and anteroposterior and lateral views of the whole femur is mandatory in the radiological evaluation of suspected FNOF cases. The frog lateral view is contraindicated as it might displace the fracture fragments further. Cross-table lateral radiographs are useful in the assessment of the femoral neck version as it may influence the choice of implant. Literature evidence suggests an increased risk of treatment failure when fractures are fixed with >20 degrees of posterior tilt.

CT scan provides a better delineation of the fracture pattern and comminution and helps in optimal treatment planning.

Suspected pathological fractures and occult fractures which are not evident on plain radiographs are better evaluated using magnetic resonance imaging scans [12].

Classification of Fracture Neck of Femur

FNOF in adults are usually classified using the Garden's and Pauwel's classification systems [4, 6-8, 11].

Garden's classification considers the extension of the fracture line, displacement of the fracture fragments and alignment of the primary compressive trabeculae at the neck, head and acetabular source (Table 1).

Pauwel's classification (Type I < 30 degrees; type II 30 -70 degree, type III > 70 degrees) introduced in 1935 is based on the

Stage	Fracture line	Displacement	Trabecular orientation	Stable/ unstable	Complications	Outcome
I	Incomplete	Undisplaced or Valgus impacted	Continuity maintained; In valgus type, angulation at neck and head fragments	Stable	In valgus impaction kinking of posterosuperior blood vessels can occur	Good
II	Complete	Undisplaced	No malalignment	Stable	Low risk of Non-union and AVN	Good
III	Complete	Partially displaced	Mal-aligned at all three places	Unstable; Femoral head in varus	AVN + Non-union ++	Poor
IV	Complete	Completely displaced and femoral head rotate back to an anatomic position	Break-in continuity between neck and head, but aligned between head and acetabulum	Unstable; Severe posterior comminution	AVN +++ Non-union ++	Poor

angle formed by the fracture line with the horizontal. Though, used less often it is a good predictor for the union of FNOF. An obtuse (high) Pauwel's angle of >50 degrees is associated with posteroinferior comminution and loss of integrity of the calcar femorale in around 96 % of cases. Higher angle/verticality of the fracture leads to greater shearing forces which result in biomechanically unstable fracture pattern and increases the risk of malunion, non-union and avascular necrosis [4, 8, 12, 13].

Treatment of Fracture Neck of Femur

Goal of treatment in young patients are threefold: (1) To achieve anatomic reduction to preserve blood supply and prevent osteonecrosis (2) To provide stable fixation to achieve bone union and (3) To return to pre-injury level of function. Preserving the natural anatomy and mechanics of the hip joint is absolutely critical to achieving these goals [2, 4, 6].

Treatment planning requires a proper assessment of patient-

related (activity level, life expectancy and medical comorbidities) and fracture-related (location, orientation and comminution) factors [12]. There is no consensus in literature with regards to the timing of surgery, choice of implants, reduction strategies (open versus closed) and configuration of fixation and these continue to be still debated with varying results.

The timing of surgery plays a key role in the union of FNOF. Internal fixation after more than 24 hours could significantly increase the odds of non-union. However, no strong evidence was found with the timing of surgery and the occurrence of osteonecrosis. Barnes et al who followed up 1503 fractures found no significant difference in the incidence of osteonecrosis by delaying the fixation up to one week [2, 4, 14]. Current recommendation for successful internal fixation of FNOF in young adults include (a) Fracture fixation within 12 hours of injury or as soon as possible, (b) Anatomic reduction through closed methods or if necessary by open reduction and (c) Rigid fixation with some form of a stable fixation device. Implants which permit load-bearing like dynamic hip screws with anti-rotation screws or intramedullary nails should be considered in mechanically unstable fracture pattern. Sub capital or transcervical fracture patterns and non-comminuted fractures are mechanically stable and enable load sharing and can be soundly fixed with cannulated screws or a sliding hip screw system alone [4, 5, 7, 11].

Reduction Techniques

Reduction of the displaced fracture fragments can be achieved by closed, percutaneous or open techniques.

Closed Reduction

In the closed techniques, there is no control over the head fragment. Therefore, the distal fragment has to be manipulated and brought into alignment with the proximal fragment. Commonly described techniques to achieve closed reduction are those by Leadbetter, Flynn and Whitman [11, 15].

In Leadbetter's technique (1939) the affected hip and knee of the fractured limb are flexed to 90 degrees with slight abduction of the hip. An assistant stabilizes the pelvis. While maintaining the vertical traction on the femur, the leg is fully internally rotated and then brought into extension and mild abduction. Finally, the foot is anchored to the fracture table boot and anatomical reduction is verified with the fluoroscope [6, 15].

In Flynn's technique (1974), with the patient lying supine on the fracture table, the hip is gently flexed to beyond 90 degrees along with 10 degrees of abduction and neutral rotation. While an assistant steadies the foot the surgeon applies traction in line with the neck of the femur with one hand and steadies the knee with the other. Internal rotation is then applied to the hip and the leg is extended and finally secured in extension, internal rotation and mild abduction. Flexion of the hip beyond 90

degrees may cause significant stretch of the posterior capsule and compromise the blood supply to the head of the femur. Hence, this technique is not recommended for completely displaced fractures [16].

In Whitman's method (1927), the reduction is achieved by applying longitudinal traction to the leg with the hip in extension and internal rotation [6].

Once the reduction manoeuvre is performed the 'heel-palm test' may be employed to check the reduction. On placing the heel of the patient on the surgeon's palm, if the fracture is anatomically reduced, the limb will not go into external rotation. The tips in getting an acceptable reduction are understanding the three-dimensional anatomy before manipulation and provide non-vigorous traction, minimal internal rotation and abduction. Massive traction, coarse manipulation and too much internal rotation may hamper reduction and cause further damage to the vascularity of the head of the femur [17]. Except for varus mal-reduction, a reduction in mild valgus or a single or dual cortical step with a cross-sectional area of bony contact of >75% may be accepted.

Percutaneous Reduction

The invasive (percutaneous) technique by Su et al. employs Steinman pins or Kirschner wires as joysticks to control the movement of the proximal femur. The femoral artery is palpated and the pin is inserted 1.5–3 cm lateral to the femoral artery into the middle two-third of the femoral head (Figure 1a) [18].

In the percutaneous technique described by Mahajan et al, a threaded transfixing guidewire is passed from the superolateral aspect of the femoral head towards the inferomedial aspect to enter the teardrop (Figure 1b). Thereafter, in a gentle controlled manner, the distal fragment is brought to align with the proximal fragment to achieve the acceptable reduction [15].

Figure 1: The percutaneous technique of using K-wires to control the head fragment to facilitate closed reduction as described by Su (a) and Mahajan (b).

Open reduction

Is usually performed through the Modified Smith Peterson or Watson Jones approach [4, 12].

The modified Smith-Peterson approach proceeds along the inter-nervous plane between Sartorius and Tensor fascia lata superficially and between the gluteus medius and rectus femoris in the deeper plane. It provides superior exposure of the femoral neck and articular surface as compared to the Watson-Jones approach.

In Watson-Jones anterolateral approach the dissection proceeds between the tensor fascia lata and gluteus medius muscles and is preferred in reduction of transcervical or basicervical fractures, but not for sub-capital fractures as articular exposure is limited. This approach double up to facilitate reduction of the neck fracture and provide access to the lateral surface of the femur through the same exposure [7, 11].

In both approaches, an anterior capsulotomy is performed using a 'T' or 'L' shaped incision with the long limb of the capsulotomy along the femoral neck and the transverse limb bordering the capsulolabral junction. External rotation of the leg permits exposure of the inferomedial neck and facilitate the placement of an infero-medial buttress plate if indicated.

Although the exact incidence of injury to the lateral femoral cutaneous nerve associated with open reduction of FNOF is unknown, it is reported to be higher with the modified Smith-Peterson approach and cautious dissection is recommended.

No difference is reported in comparing open reduction with closed reduction with respect to non-union (14.9% vs 11.6%) and avascular necrosis (17.7% vs. 17.2%) [9].

Cortical Buttress Reduction

Gotfried et al introduced a non-anatomic functional reduction pattern known as the cortical buttress reduction (Figure 2).

In the usual anatomic reduction pattern, the head-neck

Figure 2: Non-anatomic cortical buttress reduction as described by Gotfried where the proximal fragment is supported by the inferior calcar cortex.

fragment is only supported by the fixation screw [19]. In Gotfried's technique, intentionally the proximal head-neck fragment is displaced superiorly into the distal fragment by 4 mm/one cortical thickness so that the head-neck is supported and upheld by the inferior calcar cortex. This also tilts the head into a mild acceptable valgus position. This non-anatomic pattern is considered an excellent alternative to anatomical reduction and is easy to achieve by a closed manoeuvre. After fixation, the femoral head-neck is dual supported by the fixation screw and the calcar cortex. The inferior calcar support resists the vertical shear forces and converts these forces to achieve compression at the fracture site. From their study, the authors showed that this construct can provide both mechanical and biological environment for fracture stability and union [3, 19].

Assessment of Reduction

The quality of reduction can be determined using Garden's alignment index. It describes the angle formed by the compressive trabeculae of the femoral head-neck segment with the longitudinal axis of the femoral shaft in the anteroposterior and lateral hip radiographs. Lateral view using fluoroscope angulated at 15 degrees to the floor helps to assess the anteversion of the neck. An angle of 160 degrees to 180 degrees in the anteroposterior and lateral view represents an anatomic reduction. Up to 15 degrees of valgus angulation is acceptable while a varus angle less than 160 degrees is unacceptable. Similarly, a posterior angulation of more than 5 degrees in lateral view is unacceptable. The acceptable reduction corresponds to a neck-shaft angle of 130-150 degrees in anteroposterior view and 0-15 degrees of ante-version in the lateral view. Literature evidence suggests that non-anatomic reduction, specifically varus malreduction and inferior offset increases complications leading to poorer outcome and reoperation. However, minimal valgus alignment does not lead to inferior outcome [4, 6, 15, 20].

Role of Capsular Decompression

Hemarthrosis following FNOF can have a tamponade effect on the vascularity to the femoral head. Additionally, traction, extension and internal rotation also raise the intracapsular pressure. The likelihood of AVN is increased when the intracapsular pressure difference between the two hips is more than 30 mm Hg. The theoretical advantage of capsular decompression is to let out the intracapsular hematoma which would relieve the pressure on the blood vessels and improve femoral head circulation. But, Maruenda et al found no correlation between raised intracapsular pressure and femoral head perfusion [21]. They further showed no difference in intra-capsular pressure between displaced and undisplaced fractures. Disruption of the hip capsule during fracture fragment displacement is postulated as a reason for the

Figure 3: Ideal placement of cancellous screws in an inverted triangle fashion with the inferior most screw proximal to the lesser trochanter.

Figure 4: Four screws placed in a diamond configuration. They may also be placed anterosuperior, anteroinferior, posterosuperior and posteroinferior and improve the stability of fixation.

Figure 5: Transverse (Pauwel's) screw passing perpendicular to the fracture line into the infero-medial portion of the femoral head resisting shear forces.

spontaneous decompression of the intra-capsular hematoma [7,13].

Internal Fixation of FNOF

Cancellous screw fixation: The decision to use multiple cancellous screws or dynamic hip screw will depend on the fracture displacement, posterior comminution, verticality of the fracture line and quality of the bone. In an undisplaced or minimally displaced non-comminuted, low angle or valgus impacted fracture, cannulated cancellous screw fixation is preferred. Typically, 3 partially threaded 6.5 or 7.3 mm cannulated cancellous screws are inserted peripherally close to the femoral neck cortex in a parallel or divergent 'inverted triangle' configuration (inferior, posterosuperior, anterosuperior) (Figure 3) [3,4,11,22–26].

The inferior and posterior screws resist inferior and posterior displacement of the femoral head respectively. The posterior screw should be inserted slightly posterior to the femoral shaft axis. This screw configuration is shown to withstand vertical shear forces, provide fracture stability and achieve bony union [6,11,26–28]. The insertion point of the inferior screw on the lateral cortex must be at or above the level of the lesser trochanter to minimize the stress riser effect in the subtrochanteric region [27]. The risk of subtrochanteric fracture may also be reduced by the inverted triangle pattern. The screw threads should completely cross the fracture line and lie within the femoral head to achieve better compression and the screw tip should end within 5 mm of the subchondral bone of the femoral head. The addition of washers along with the cancellous screws helps further to improve compression [11,12].

Unacceptable fracture reduction (less contact area), failure to achieve compression at the fracture site, insufficient screw length, repeated drilling which reduces screw purchase in the femoral head, lack of parallelism and convergence of screw tips towards the head centre can predispose to failure of screw fixation. Weight-bearing on the imperfect mechanical

construct can result in uncontrolled varus collapse, nonunion and implant failure with penetration of the screws into the joint.

Fixation using 4 cancellous screws: Fracture stability can be further improved by using an additional fourth screw and positioning the screws in the peripheral dense bone in the neck. This achieves fixation in all the four quadrants of the femoral head (inferior posterior, inferior anterior, superior posterior and superior anterior quadrants) (Figure 4) [4,7,12].

Transverse screw (Pauwel's screw): High energy trauma in young adults can lead to vertical femoral neck fractures (Pauwel's type III). A technique employing two parallel 7.0-mm cancellous lag screws inserted into the neck at an angle of 125 degrees from the proximal femur and a third transverse screw (Pauwel's screw) perpendicular to the fracture line between the first two screws directed towards the inferomedial aspect of the femoral head has been described for such fractures (Figure 5) [29].

After placing the guidewires at the desired angle, the transverse screw is inserted first followed by the posterior and finally the anterior screw [11,29]. Transverse screw fixation should be reserved for young patients with good bone mass in whom stable fixation can be achieved after anatomical reduction. This promotes sound bone union and avoids telescoping of fragments and, consequently, coxa breva and femoral shortening. Femoral neck shortening of more than 5 mm is associated with inferior functional outcome and prolonged need for walking aids [11,29].

Fully threaded screw: A shortened femoral neck, as already mentioned can lead to abductor muscle weakness due to decreased abductor lever arm, besides causing actual shortening of the entire lower limb. In-situ fixation of non-displaced femoral neck fractures can be achieved by using 2 or 3 fully threaded screws without causing shortening of the femoral neck (Figure 6) [4,6,25,30].

Figure 6: Fully threaded screws which act as positional screw in the superior aspect and partially threaded screw with washer in the inferior portion of the neck.

Figure 7: Screws are placed in two different planes to improve the rotational stability of the construct.

Figure 8: Ideal position of Richards screw in the center of the femoral head with a combined Tip-Apex distance of < 25 mm in anteroposterior and lateral view.

Headless Screws: Biomechanical advantages were noted while using headless fully threaded, self-compressing screws [25, 30].

Biplane Double Supported Screw Fixation (BDSF): Filipov et al devised a method in which two of the three screws are laid in two planes [31]. The entry points of middle and distal screws are placed in the distal solid cortex of proximal diaphysis. BDSF method uses two calcar buttressed screws. The distal screw is placed in the dorsal oblique plane while the middle and proximal screws are inserted in the ventral oblique plane. The middle and proximal screws are inserted first followed by the distal screw as they are perpendicular to the fracture surface. (Figure 7) [31, 32].

Dynamic hip screw (DHS) or dynamic condylar screw (DCS) with de-rotation screw: In highly unstable fracture patterns (Pauwel's type III, basi-cervical and fractures with posterior comminution), sliding hip screw with anti-rotation screw confers greater stability as they resist shear forces better than multiple cancellous screws (Figure 8).

Though the DHS group has greater soft tissue trauma and blood loss, longer operating time and increased cost of treatment than the CC screw group, early weight-bearing and fracture union, lower complication rate (especially non-unions) and superior Harris Hip Score are considered as advantages of DHS [4, 6, 7, 23]. The aim is to place the compression screw (Richard's screw) in the dense central-central location (or inferior and posterior) in the AP and lateral views. Attention needs to be paid to achieve a combined tip-apex distance of 10-25 mm in both views to have a better subchondral screw purchase. Also, the length of the de-rotation screw inserted superior to the compression screw should be shorter than the compression screw to prevent inadvertent penetration into the hip joint in the event of osteonecrosis/collapse.

Femoral Neck System (FNS): Is designed for improved angular and rotational stability. It consists of a bolt, an anti-rotation screw and one or two holed side plate (Figure 9).

Bolt has a cylindrical design intended to maintain the reduction during insertion and provide angular stability. Anti-rotation screw provides rotational stability. The plate is designed to accommodate standard 5.0 mm locking screws and provide minimized implant footprint and angular stability. The bolt together with the anti-rotation screw slides only up to 20 mm. This guided collapse is designed to reduce lateral protrusion. FNS showed less inferior shearing displacement of the femoral head and a greater load to failure when compared to fixation with three cannulated screws [33, 34]

Proximal Femur Locking Compression Plate (PFLCP): Clinical and biomechanical studies have shown higher failure rates with PFLCP. Incorrect insertion of the locking screws leading to their breakage or loosening is identified as the main reason for these failures [23, 35]. Advanced designs in PFLCP involves combining fixed-angle technology with parallel

Figure 9: Femoral neck system consisting of antirotation screw, a bolt and side plate which permit controlled collapse and prevent lateral protrusion. (Courtesy Dr. Rajaneesh R, Baby Memorial Hospital, Kerala)

Figure 10: Targon system with 'Tele-Screws' attached to an anatomically shaped locking side plate permits controlled collapse.

Figure 11: Inferomedial plate provide a biomechanically stronger construct and convert shearing forces to compression forces in Pauwel's type III fracture pattern.

telescoping screws, which allows controlled compression via a dynamic sliding mechanism.

Dynamic locking plate (Targon Femoral Neck Hip Screw, Targon FN. Aesculap Ltd, Tuttlingen, Germany) incorporates all the optimum features from the sliding hip screw and multiple cancellous screws. This implant provides dynamic fracture fixation with up to four 6.5 mm cancellous 'Tele-Screws' which has an integrated telescoping capacity of 10–20 mm. The 'Tele-Screws' are attached to an anatomically shaped locking side plate, which is fixed to the femoral shaft by two 4.5 mm bicortical screws (Figure 10). This construct can provide dynamic controlled collapse of the femoral neck, rotational stability, secure fixation of the side plate and prevent backing out of Tele-screws [1].

Cephalomedullary Nailing: Intramedullary (IM) nail with a helical blade is generally considered for basicervical FNOF or when there is a combination of the neck with the shaft of femur fracture. Compared to the extra-medullary DHS/DCS, the IM nail is placed more medially and thereby is closer to the mechanical axis of the body's centre. This decreases the bending moment on the implant. In addition, despite the collapse occurring at the fracture site in extra and intramedullary groups, the nail buttresses the medial cortex of the proximal fragment more efficiently and prevent further collapse at the fracture site. It was also noted that the helical blade has enhanced purchase in the femoral head as it conserves the bone which is otherwise lost during drilling and insertion of Richard's screw [20, 23, 36].

Inferomedial Plating: In Pauwels type III fractures, the mechanical resistance of fixation with multiple cancellous

screws can be improved by adding a buttress plate in the inferomedial aspect of the femoral neck (Figure 11).

Inferomedial plate converts shearing forces into compression forces and optimizes the function of the cancellous screws running parallel to the femoral neck axis [24, 37]. This construct is shown to be biomechanically stronger than cannulated cancellous screws or sliding hip screw alone. A 4-6 hole one-third tubular under contoured plate is placed on the infero-medial part of the femoral neck and fixed with screws. Under-contouring pushes the plate to the cortex while tightening the screws and create more buttress force against the medial femoral neck [17]. The inferomedial buttress plate may be employed after the primary fixation of the fracture. The exposure for plate placement can be improved by externally rotating the hip. Iatrogenic impingement should be negated by avoiding too superior or anterior placement of the buttress plate [11, 17, 26, 37].

Decision Making in Elderly Patients

The primary goal of treatment of FNOF in the active elderly population is the early restoration of pre-morbid walking ability to improve the quality of life and lessen the possibility of morbidity and mortality. Undisplaced fractures in elderly patients may be managed with internal fixation. However, the surgeon should be aware that the complication profile (risk of reoperation for removal of symptomatic implants, non-union and mortality) following the treatment of un-displaced FNOF in the elderly by osteosynthesis exceeds 14% [38]. Independent predictors of nonunion and reoperation were age and posterior tilt angle. The cut-off value for age and the posterior tilt angle for reoperation were 72.5 years and 13 degrees respectively [6, 39].

The general consensus is to consider arthroplasty as it allows rapid and safe mobilization of these elderly patients without concern of osteosynthesis or union [6, 38, 40].

Decision making in the management of displaced FNOF in elderly patients is based on physiological age, comorbidities, Charlson's Comorbidity Index (CCI), walking ability, mental status and home circumstances. CCI estimates the 10-year survival rate in patients based on comorbidities. CCI takes into account age and co-existing diseases, giving each item a different weight (coronary artery disease, congestive cardiac failure, obstructive lung disease, cerebrovascular accident, dementia, diabetes mellitus, chronic kidney disease, connective tissue disease, acid peptic disease, chronic liver disease, peripheral vascular disease, malignancies and AIDS) [41]. Increased rate of complications is noted with CCI ≥ 8 [41, 42].

Role of Total Hip Arthroplasty

Current evidence is that total hip arthroplasty (THA) is a better choice for displaced FNOF in patients aged 60-80 years if they are mentally lucid, healthy, agile and capable of living independently or have pre-existing hip arthritis [43]. They can engage in recreational activities beyond simple walking and can expect to return to their pre-fracture level of activities [44].

THA is linked with superior functional outcome, lower postoperative pain score, enhanced walking distance, better hip disability indices and has a potential decrease in reoperation rates as compared to hemiarthroplasty (HA) [45-47]. Advocates of THA criticize HA as the latter results in rapid wear of the acetabular articular cartilage [45]. Shmidt et al observed that the revision surgery rates were 33% after internal fixation, 24% after Austin Moore hemiarthroplasty and 7% after THA over a 13 year follow-up period [40, 48].

However, THA is not without complications. THA is more technically demanding resulting in greater blood loss, hematoma formation and takes longer surgical time. The incidence of infection and dislocation are also higher in THA. The risk of dislocation is more with posterior hip approaches than compared to lateral and anterior approaches. The rates of re-operation are also high in the posterior approach than the lateral approach. Meticulous capsular repair in the posterior approach or use of the anterior exposure is shown to dramatically reduce the risk of dislocation. Recent advances in bearing surfaces and usage of larger or dual mobility femoral heads, combined with improved surgical techniques have reduced the incidence of dislocations and other mechanical complications following THA [43, 49]. No significant difference was found between the approaches for intraoperative blood loss, perioperative fracture, duration of the procedure, post-operative pain levels, length of hospital stay, immediate postoperative infection rate, total complication rate and mortality [43].

Role of Hemiarthroplasty

HA is the preferred treatment in low demand and cognitively impaired elderly patients with FNOF. Predictors that favour HA were age >80 years, under-weight, dependent functional status, undergoing dialysis treatment and hemiplegia. Advantages of HA compared to THA are that it is a quicker and relatively simple and economical surgical procedure leading to improved mobility with documented lower risk of dislocation.

Recent reports comparing bipolar and unipolar show the only minimal difference between them with regard to morbidity, mortality and functional outcome. It has been shown that after one year many bipolar prostheses begin to act as unipolar over time. Despite this, bipolar heads are considered functionally superior even if they can be a source of wear debris [50].

Long term problems associated with HA lead to poor functional outcome in active patients. Symptoms include groin pain due to rapid acetabular cartilage wear, protrusio acetabuli, femoral stem loosening and subsidence [51]. More acetabular erosion was observed in uni than bipolar hemiarthroplasty, but the difference was not statistically significant. Cemented prostheses have shown lower rates of implant-related complications (particularly peri-prosthetic femoral fracture and stem loosening) and improved postoperative outcome with respect to residual thigh pain and mobility [51]. The one-year mortality after HA is 20-35% which increases to 50% in 5-years. The dislocation rate after HA is 2-11%. Revision surgery may be warranted in 30-50% of young and active patients who survive for more than three years. Conversion of HA to THA is much more difficult, requires longer operative time and may have more blood loss and increased risk of periprosthetic fractures than primary THA.

Role of Excision Arthroplasty

Girdlestone resection arthroplasty was first described by Gathorne Robert Girdlestone in 1928. This procedure is not considered the primary choice in patients with acute FNOF. The indications for excision arthroplasty include painful nonunion of the femoral neck, osteonecrosis and complications of arthroplasty or osteosynthesis. The procedure inevitably results in limb shortening. The average shortening of the limb is around 3.5 cm and is not influenced by postoperative traction. Though patients may need to use a walking aid, it usually allows an acceptable degree of functional autonomy in most cases [52].

Conclusion

In this comprehensive review based on the recent relevant literature, we have summarized the diagnostic and management approaches to a patient with suspected fracture neck of femur. We have tried to give evidence-based answers on the much-debated aspects in the management of the intracapsular

fractures of the neck of the femur. We feel this would help the surgeon in the thoughtful selection of the operative

intervention for each patient on an individual basis and also help in proper counselling of the patient.

References

1. Yin H, Pan Z, Jiang H. Is dynamic locking plate (Targon FN) a better choice for treating of intracapsular hip fracture? A meta-analysis. *International Journal of Surgery* 2018; 52: 30–34.
2. Schwartzmann CR, Lammerhirt HM, Spinelli L de F, et al. Treatment of displaced femoral neck fractures in young patients with DHS and its association to osteonecrosis. *Revista Brasileira de Ortopedia (English Edition)* 2018; 53: 82–87.
3. Wang Y, Ma J, Yin T, et al. Correlation Between Reduction Quality of Femoral Neck Fracture and Femoral Head Necrosis Based on Biomechanics. *Orthop Surg* 2019; 11: 318–324.
4. Goudie EB, Duckworth AD, White TO. Hip fractures in young adults. *Orthopaedics and Trauma* 2017; 31: 76–85.
5. Papakostidis C, Panagiotopoulos A, Piccioli A, et al. Timing of internal fixation of femoral neck fractures. A systematic review and meta-analysis of the final outcome. *Injury* 2015; 46: 459–466.
6. Pauyo T, Drager J, Albers A, et al. Management of femoral neck fractures in the young patient: A critical analysis review. *World J Orthop* 2014; 5: 204–217.
7. Ly TV, Swiontkowski MF. Treatment of femoral neck fractures in young adults. *J Bone Joint Surg Am* 2008; 90: 2254–2266.
8. Falk NW L, D K, M H, et al. Trans-Cervical Femoral Fractures in Young Adults: The Prognosis is not only in the Hands of Orthopaedic Surgeons. *Emerg Med* 2018; 08: 1–8.
9. Rogmark C, Kristensen MT, Viberg B, et al. Hip fractures in the non-elderly—Who, why and whither? *Injury* 2018; 49: 1445–1450.
10. Duckworth AD, Bennet SJ, Aderinto J, et al. Fixation of intracapsular fractures of the femoral neck in young patients: RISK FACTORS FOR FAILURE. *The Journal of Bone and Joint Surgery British volume* 2011; 93-B: 811–816.
11. Stacey SC, Renninger CH, Hak D, et al. Tips and tricks for ORIF of displaced femoral neck fractures in the young adult patient. *Eur J Orthop Surg Traumatol* 2016; 26: 355–363.
12. Florschütz AV, Langford JR, Haidukewych GJ, et al. Femoral Neck Fractures: Current Management. *Journal of Orthopaedic Trauma* 2015; 29: 121–129.
13. Rawall S, Bali K, Upendra B, et al. Displaced femoral neck fractures in the young: significance of posterior comminution and raised intracapsular pressure. *Arch Orthop Trauma Surg* 2012; 132: 73–79.
14. Cheung R. Neck of femur fracture: perioperative management. *Update in Anaesthesia* 2016; 31: 43–47.
15. Mahajan RH, Kumar S, Mishra B. Technique for gentle accurate reproducible closed reduction of intracapsular fracture of neck of femur. *Injury* 2017; 48: 789–790.
16. Flynn M. A new method of reduction of fractures of the neck of the femur based on anatomical studies of the hip joint. *Injury* 1974; 5: 309–317.
17. Ye Y, Chen K, Tian K, et al. Medial buttress plate augmentation of cannulated screw fixation in vertically unstable femoral neck fractures: Surgical technique and preliminary results. *Injury* 2017; 48: 2189–2193.
18. Su Y, Chen W, Zhang Q, et al. An irreducible variant of femoral neck fracture: a minimally traumatic reduction technique. *Injury* 2011; 42: 140–145.
19. Gotfried Y, Kovalenko S, Fuchs D. Nonanatomical reduction of displaced subcapital femoral fractures (Gotfried reduction). *J Orthop Trauma* 2013; 27: e254–259.
20. Pal C, Pruthi K, Singh P, et al. Role of proximal femoral nailing in fracture neck of femur. *J Orthop Traumatol Rehabil* 2014; 7: 59–63.
21. Maruenda JI, Barrios C, Gomar-Sancho F. Intracapsular hip pressure after femoral neck fracture. *Clin Orthop Relat Res* 1997; 172–180.
22. Liu C, Von Keudell A, McTague M, et al. Ideal length of thread forms for screws used in screw fixation of nondisplaced femoral neck fractures. *Injury* 2019; 50: 727–732.
23. Augat P, Bliven E, Hackl S. Biomechanics of Femoral Neck Fractures and Implications for Fixation. *Journal of Orthopaedic Trauma* 2019; 33: S27–S32.
24. Zhuang L, Wang L, Xu D, et al. Anteromedial femoral neck plate with cannulated screws for the treatment of irreducible displaced femoral neck fracture in young patients: a preliminary study. *Eur J Trauma Emerg Surg* 2019; 45: 995–1002.
25. Zhang B, Liu J, Zhu Y, et al. A new configuration of cannulated screw fixation in the treatment of vertical femoral neck fractures. *International Orthopaedics (SICOT)* 2018; 42: 1949–1955.
26. Guo J, Dong W, Qin S, et al. Definition of ideal configuration for femoral neck screw fixation in older people. *Sci Rep* 2019; 9: 12895.
27. Callaghan JJ, Liu SS, Haidukewych GJ. Subcapital fractures: a changing paradigm. *The Journal of Bone and Joint Surgery British volume* 2012; 94-B: 19–21.
28. Giordano V, Paes RP, Alves DD, et al. Stability of L-shaped and inverted triangle fixation assemblies in treating Pauwels type II femoral neck fracture: a comparative mechanical study. *Eur J Orthop Surg Traumatol* 2018; 28: 1359–1367.
29. Guimarães JAM, Rocha LR, Noronha Rocha TH, et al. Vertical femoral neck fractures in young adults: a closed fixation strategy using a transverse cancellous lag screw. *Injury* 2017; 48: S10–S16.
30. Chiang M-H, Wang C-L, Fu S-H, et al. Does fully-threaded Headless Compression Screw provide a length-stable fixation in undisplaced femoral neck fractures? *Asian Journal of Surgery* 2019; 42: 320–325.
31. Filipov O. Biplane double-supported screw fixation (F-technique): a method of screw fixation at osteoporotic fractures of the femoral neck. *Eur J Orthop Surg Traumatol* 2011; 21: 539–543.
32. Kalia A, Singh J, Ali N. Role of Biplane Double Supported Screw Fixation For Fracture Neck Femur In Elderly Population: A Prospective Study. *TOORTHJ* 2018; 12: 514–524.
33. Stoffel K, Zderic I, Gras F, et al. Biomechanical Evaluation of the Femoral Neck System in Unstable Pauwels III Femoral Neck Fractures: A

- Comparison with the Dynamic Hip Screw and Cannulated Screws. *J Orthop Trauma* 2017; 31: 131–137.
34. Zhou X, Li Z, Xu R, et al. Comparison of Early Clinical Results of Femoral Neck System and Cannulated Screws in the Treatment of Unstable Femoral Neck Fractures. Preprint, In Review. Epub ahead of print 18 December 2020. DOI: 10.21203/rs.3.rs-129837/v1.
 35. Samsami S, Saberi S, Sadighi S, et al. Comparison of Three Fixation Methods for Femoral Neck Fracture in Young Adults: Experimental and Numerical Investigations. *J Med Biol Eng* 2015; 35: 566–579.
 36. Guo J, Dong W, Yin B, et al. Intramedullary nails with cannulated screw fixation for the treatment of unstable femoral neck fractures. *J Int Med Res* 2019; 47: 557–568.
 37. Giordano V, Alves DD, Paes RP, et al. The role of the medial plate for Pauwels type III femoral neck fracture: a comparative mechanical study using two fixations with cannulated screws. *J EXP ORTOP* 2019; 6: 18.
 38. Dolatowski FC, Frihagen F, Bartels S, et al. Screw Fixation Versus Hemiarthroplasty for Nondisplaced Femoral Neck Fractures in Elderly Patients: A Multicenter Randomized Controlled Trial. *The Journal of Bone and Joint Surgery* 2019; 101: 136–144.
 39. Robertson GA, Wood AM. Hip hemi-arthroplasty for neck of femur fracture: What is the current evidence? *WJO* 2018; 9: 235–244.
 40. Baker RP, Squires B, Gargan MF, et al. Total Hip Arthroplasty and Hemiarthroplasty in Mobile, Independent Patients with a Displaced Intracapsular Fracture of the Femoral Neck: A Randomized, Controlled Trial. *JBJS* 2006; 88: 2583–2589.
 41. Charlson M, Szatrowski TP, Peterson J, et al. Validation of a combined comorbidity index. *Journal of Clinical Epidemiology* 1994; 47: 1245–1251.
 42. Bigoni M, Turati M, Leone G, et al. Internal fixation of intracapsular femoral neck fractures in elderly patients: mortality and reoperation rate. *Aging Clin Exp Res* 2020; 32: 1173–1178.
 43. Schmidt AH, Leighton R, Parvizi J, et al. Optimal Arthroplasty for Femoral Neck Fractures: Is Total Hip Arthroplasty the Answer? *Journal of Orthopaedic Trauma* 2009; 23: 428–433.
 44. Miller CP, Buerba RA, Leslie MP. Preoperative Factors and Early Complications Associated With Hemiarthroplasty and Total Hip Arthroplasty for Displaced Femoral Neck Fractures. *Geriatr Orthop Surg Rehabil* 2014; 5: 73–81.
 45. Blomfeldt R, Törnkvist H, Eriksson K, et al. A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. *JBJS* 2007; 89: 160–165.
 46. Hedbeck CJ, Enocson A, Lapidus G, et al. Comparison of Bipolar Hemiarthroplasty with Total Hip Arthroplasty for Displaced Femoral Neck Fractures: A Concise Four-Year Follow-up of a Randomized Trial*. *JBJS* 2011; 93: 445–450.
 47. Nikitovic M. Total Hip Arthroplasty Versus Hemiarthroplasty for Displaced Femoral Neck Fractures: A Rapid Review. *Rapid Review* 2013; 1–22.
 48. Maceroli M, Nikkel LE, Mahmood B, et al. Total Hip Arthroplasty for Femoral Neck Fractures: Improved Outcomes With Higher Hospital Volumes. *Journal of Orthopaedic Trauma* 2016; 30: 597–604.
 49. Ukaj S, Zhuri O, Ukaj F, et al. Dual Mobility Acetabular Cup Versus Hemiarthroplasty in Treatment of Displaced Femoral Neck Fractures in Elderly Patients: Comparative Study and Results at Minimum 3-Year Follow-up. *Geriatr Orthop Surg Rehabil* 2019; 10: 1–7.
 50. Hedbeck CJ, Blomfeldt R, Lapidus G, et al. Unipolar hemiarthroplasty versus bipolar hemiarthroplasty in the most elderly patients with displaced femoral neck fractures: a randomised, controlled trial. *International Orthopaedics (SICOT)* 2011; 35: 1703–1711.
 51. Pace TB, Prather B, Burnikel B, et al. Comparative Outcomes Assessment: Hip Hemiarthroplasty as an Alternative to THA in Patients with Surgically Pristine Acetabulum—Is There Still a Role? *ISRN Orthopedics* 2013; 2013: 1–6.
 52. Sawadogo M, Kafando H, Ouedraogo S, et al. Is Head and Neck Resection of the Femur (Girdlestone's Procedure) Still Relevant? Indications and Results About 24 Cases. *TOORTHJ* 2018; 12: 69–74.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

How to Cite this Article

Vijayan S, Hegde N, Kulkarni MS, Aroor MN, Bhat V, Rao SK | The 'Unsolved' Fracture Neck of Femur – A Comprehensive Review | *Journal of Karnataka Orthopaedic Association* | August-September 2021; 9(2): 02-11.