

Trans-Cervical Femoral Fractures in Young Adults: The Prognosis is not only in the Hands of Orthopaedic Surgeons

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Abstract

Hip fractures are still a very difficult problem in emergency rooms all over the world. They are increasingly common due to increasing numbers of road accidents and aging population. They are among the most expensive injuries treated in emergency rooms. If surgical indications are rather well codified for older injured, the goals to achieve for younger ones is quite different. Restoring or preserve the femoral head vascular supply is of utmost importance and requires a perfect coordination between emergency specialists and orthopaedic surgeons.

In this context, reducing the delay between the injury and consider these fractures as real surgical emergencies as well as improving surgical techniques to allow a fast rehabilitation are the management options which can help emergency teams to improve their final results. For these traumas the preservation of the femoral head is the goal we all expect to achieve.

Keywords: Trans-cervical femoral fractures; Emergency teams; Orthopaedic surgeons

Introduction

Most of hip fractures occur in the elderly and are associated to a high morbidity and mortality rates during the first year, especially for those with previous renal failure.

Regarding younger injured, hip fractures (HF) remain a difficult challenge as they often lead to severe, immediate or delayed complications. Except the common difficulties we're all experiencing in the early pre or post-operative period, the A-Vascular Necrosis (AVN) is probably one of utmost importance regarding the final prognosis and the quality of the joint function. The major goal for these patients is to "save" the femoral head in order to avoid any early Total Hip Replacement (THR). Reducing the delays before surgery needs so a perfectly trained emergency team, and regarding these fractures as real emergencies is certainly the key of a successful treatment and a perfect prognosis.

We've so improved our local procedures in order to reduce these pre-operative delays, set up a new surgical technique and edited new rules to be able to perform their surgery as fast as possible and so improve our results. To do so, the most important element during and after the admission of these young injured is certainly to enhance the perfect cooperation between surgeons and emergency specialists in charge of these patients.

Physiopathology

Simple falls are the most common causes of hip fractures in elderly people (low energy trauma) and their treatment is rather well codified. Despite severe immediate and secondary general complications, surgery gives very good functional results (hemi or total hip arthroplasty when simple screwing or any conservative treatments are not indicated). For younger ones the context is quite different and we usually have to manage most serious situations (high energy traumas) such as: road accidents, falls from high, whatsoever the type of initial impact : foot, knee, lateral hip, etc.

In these situations, the first preoccupation is of course to set-up a full check-up while vital signs have to be monitored and restored. For these, Emergency Specialists (ES) are perfectly trained to take care of these patients in such conditions, sometimes in co-operation

with anesthetists and general or specialized surgeons whose decisions prevail on any other ones [1-6].

Once these problems solved, a full assessment of hips, pelvic belt and other specific orthopedic sites (spine for example) must be performed. An urgent CT-Scanner is usually recommended and necessary (Total injected CT-Body), when available (but doesn't obviate a full clinical evaluation by a trained orthopaedic surgeon). Whatsoever the situation, simple X-Rays must systematically be performed on these specific areas to avoid any misdiagnosis and to perform a better assessment of fracture sites.

For these patients, usual rules are truer than ever: "we always miss something in multiplied injured patients, and no matter what it is if it's a simple toe fracture, but for other injuries the consequences are significantly higher...".

Once these explorations performed, the fracture must be classified in order to plan the appropriate surgical treatment.

Many classifications exist for these cervical fractures. We'll exclude from our description:

- Femoral head fractures (PIPKIN's classification)
- Cervico-trochanteric fractures
- Per-trochanteric fractures
- Sub-trochanteric fractures
- Trochantero-diaphysis fractures

Some of them are most of the time treated in a similar way as cervical fractures (except for femoral head fractures) and respond

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to comparable biomechanical rules (for many orthopaedic surgeons today, percutaneous nailing seems to be a “gold standard”) [7-11].

So, regarding sub-capital, trans-cervical and basi-cervical fractures, the classifications provided intend to evaluate the remaining vascular supply of the femoral head and this is probably one of the most important prognosis factor regarding further possible necrosis (AVN), the treatment of which is still subject of debate. For these fractures the healing potential is limited due to the intra-capsular position of the fracture which bathes in synovial fluid.

The vascularization of proximal femur plays so a key role in evaluating treatment modalities and conditions of vascular compromise situations leading to delayed or non-unions as well as AVN. So, the possibility of a compromised blood flow must be taken in account anytime before deciding which therapeutic options are available. The femoral head vascular supply is rather complex (MFCA, LFCA, superficial femoral and deep femoral arteries, nutrient arteries, ...) but for the surgeon, three main systems are taken in account: Anterior Circumflex Artery (ACA), Artery of Ligamentum Teres (ALT) and Posterior Circumflex Artery (PCA), this last one giving 2/3rd of the vascularization of the superior portion of the femoral head. As being the penetration point of epiphyseal vessels, the lateral margin of the femoral head-neck looks to be a critical area rather well correlated to many secondary vascular complications. In a same way, the vascular circle around the greater trochanter looks rather fragile and must be preserved during surgery (it's injury during nailing might explain some nailing failures with fast lag screw cut-out) (Figure 1) [12-16].

Classifications

Regarding these fractures, the most popular classification among orthopaedic surgeons is the GARDEN classification. It is often used as a displacement scoring, but in fact is mainly a vascular-risk grading taking in account both bony posterior comminution and soft tissues damages around the hip (synovium, ligaments, retinacular arteries, ...). It is rather simple and easy to use and evaluates with accuracy the relationship between fracture's characteristics and average of secondary AVN. This classification is based on analysis of femoral and acetabular trabeculae patterns.

For this classification: “the more the posterior comminution, the higher the risk of AVN”.

- **Garden stage I:** Un-displaced, or incomplete, or valgus impacted fractures/STABLE FRACTURES (aspect close to greenstick fractures).
- **Garden stage II:** Un-displaced but complete/RATHER STABLE FRACTURES (no disturbance of the medial trabeculae).
- **Garden stage III:** Complete fracture but limited displacement/UNSTABLE FRACTURES – VASCULAR RISK + (femoral head tilted into a varus position; intact Weitbrecht Retinaculum).
- **Garden stage IV:** Complete fracture, severely displaced/UNSTABLE FRACTURES – VASCULAR RISK +++ (severe posterior comminution with vascular compromise. The femoral head remains aligned normally) (Figure 2).

The PAUWELS classification, which was introduced in 1935, is less used despite its interest. It is rather a good predictor for union, delayed or non-union of femoral neck fractures. This classification is based on the angle between the fracture and the horizontal line. It gives a good idea of the balance between shearing and compressive forces.

- **Type I:** angle up to 30° – Predominant compressive forces

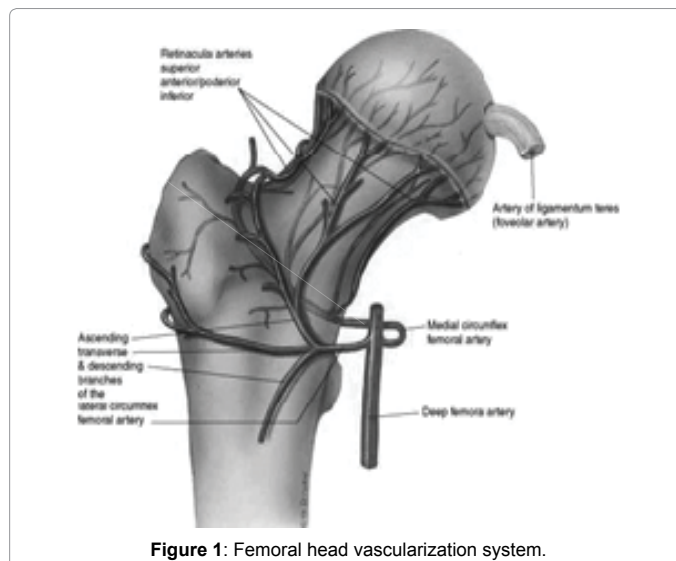


Figure 1: Femoral head vascularization system.

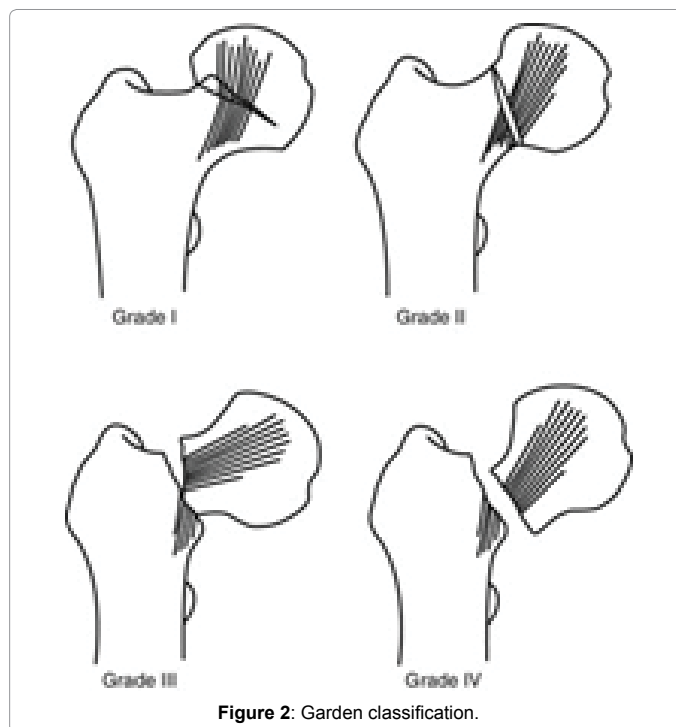


Figure 2: Garden classification.

- **Type II:** 30°–50° – Balance between shearing and compressive forces.
- **Type III:** 50° and more – Predominant shearing forces (increasing rate of complications) (Figure 3).

One classification has been forgotten by most of orthopaedic surgeons but remains interesting to score the fracture displacement and assess the real vascular risk. It has been described by LAMARE a long time ago. It is available only for GARDEN type 3 and 4 and quantifies the displacement.

- **Type I:** limited displacement
- **Type 2:** severe displacement

This classification is rather well correlated with the incidence of secondary AVN (Figure 4).

Many other classifications exist: DELBET, RAMADIER, AO, etc.

AO classification:

- Type B1 / Sub-capital fracture - No or minimal displacement
 - B 1.1 impacted in valgus > 15 degrees
 - B 1.2 impacted in valgus < 15 degrees
 - B 1.3 non-impacted
- Type B2 / Trans-cervical
 - B 2.1 basi-cervical
 - B 2.2 mid-cervical with adduction
 - B 2.3 mid-cervical with shear
- Type B3 / Displaced sub-capital fractures
 - B 3.1 moderately displaced in varus and external rotation

- B 3.2 moderately displaced with vertical translation and external rotation
- B 1.3 markedly displaced

In conclusion, if the vascular risk increases along GARDEN and LAMARE classifications, PAUWELSone is rather efficient to assess delayed and non-union risk.

Which treatment, which surgery?

Whatsoever the situation, the main goal for these young adults is therefore to prevent AVN of the femoral head, the treatment of which remains controversial. Despite early good results from ortho-biological conservative treatments, Total Hip Replacements (THR) remain a surgical standard and give good results but should be considered as too much early procedures and real failures of previous treatments [17-23].

There is no doubt that GARDEN 1 fractures, if stable, indicate conservative procedures, depending on associated lesions and other necessary treatments. In some cases, a fixation with or without complementary reduction may be discussed. Anyway, the decision made should allow a fast rehabilitation and an early physiotherapy with full or partial initial weight bearing.

For GARDEN 2 fractures, the choice is more difficult and the decision is usually made regarding the remaining amount of stability evaluated from the PAUWELS classification. In this group, stable fractures classified PAUWELS 1 and maybe 2, could be treated in a similar way as GARDEN 1 fractures. Here, the risk is a secondary displacement leading to severe and difficult secondary complications. They are so often treated surgically and the method commonly used may vary from percutaneous techniques (Closed Reduction Internal Fixation - CRIF) under fluoroscopy like simple triple screwing (whatsoever the technique: simple parallel screwing, Judet's montage, ...) or open procedures (Open Reduction Internal Fixation - ORIF) such as screw-plate.

For Garden 1 and 2 fractures treated surgically, the non-union rate is evaluated for many authors around 5% as AVN rate was estimated, for the best series, around 10%. For GARDEN 3 and 4 fractures, and whatsoever their LAMARE grading, there is no other option but surgery even if the technique remains controversial. Here various techniques are used depending mostly on personal choices. Anyway, CRIF patients do better than all others.

Regarding the literature, the complications rates for these last patients remain rather high: up to 33% for non-unions, 16% for AVN (but up to 80% for worse series in G4L2 group) and almost 30% of operated patients go to a conversion procedure by salvage THR. Whatever the technique the procedure must achieve a perfect reduction and rotational control.

The AVN risks increases with: head rotation (foveal blood supply), bad reduction, remaining valgus and posterior comminution as the non-union risk increases with remaining varus, anteversion or retroversion of more than 20 degrees and posterior comminution... The young age might be a protective factor.

In any situation, and even if the delay is still subject to debate and remains controversial, the urgent reduction of femoral neck fractures has been shown to reduce the risk of avascular necrosis. According to most of authors, 6-9 hours should be a maximum delay to proceed with the surgery.

So, the overall AVN risk factors seems to be related to: delayed reduction, poor reduction, initial displacement (displaced: 20 to 80%

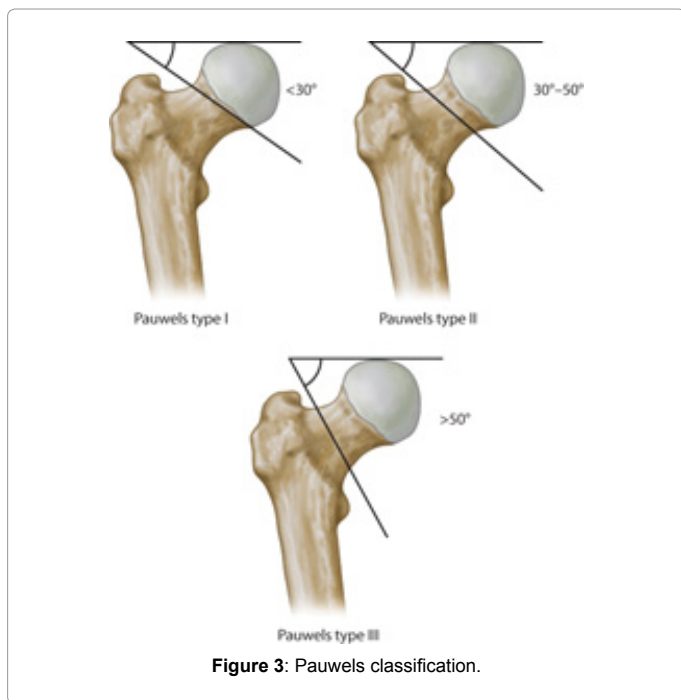


Figure 3: Pauwels classification.

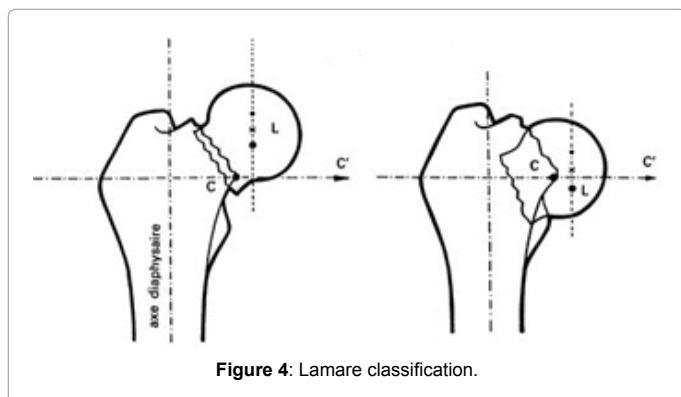


Figure 4: Lamare classification.

and undisplaced #10%), fracture grading (G3-4 and L2), initial injury velocity (Figure 5).

To avoid this complication, the best implant should therefore: allow per-operative fracture compression, remain stable in any situation, preserve or restore the local blood supply, permit immediate physiotherapy and if possible allow early weight-bearing and further fracture compression.

None of current techniques or materials have such properties. We've thus made a quite different choice for these GARDEN 2, 3 and 4 fractures due to our involvement during the GAMMA Nail conception and early trials in Strasbourg (Stryker™, France). As we all know, this nail is theoretically contra-indicated for cervical femoral fractures due to the rotational forces applied on the femoral head during the insertion of the lag screw. These forces lead to severe and unacceptable rotation of the fracture site and usually displace the fracture in a pejorative manner [24-27].

We've so set-up a new technique to be able to use this nail for this specific type of fracture. The technique uses free percutaneous K-Wires inserted anteriorly through the skin into the head of the femur and stuck in the acetabulum. This allows achieving a perfect reduction and stabilizes the fracture site during both screw insertion and compression of the fracture site (Figure 6).

Achieving a perfect anatomical reduction, preserving or restoring the head blood flow, assuming a sufficient fracture site compression are indeed the best warrants of a perfect result and of a lower rate of complications. Moreover, the functional capabilities issued from this technique (immediate full-weight-bearing, early physiotherapy and immediate rehabilitation) complete the initial surgical result and lead to very good initial results. We've been since regularly using this technique (so-called LEVI's technique), using a standard or a long GAMMA nail

(130 and 125 degrees, dynamic, static or without distal interlocking screw) to fix-up these injuries with persisting good results and lower rates of complications.

Anyway, only 30% of AVN will need reoperation whereas 75% patients with non-union will require a new surgery.

Discussion

If this technique seems to give better, easier and faster results than any other one, some factors remain uncertain and look to be related to some fracture specifications (site, height, comminution, displacement, ...) (Figures 7 and 8).

For these specific fractures, the precise evaluation of the remaining vascular supply cannot be precisely assessed in emergency situations (prognostic MRI and TEP-Scan remain uncertain methods). The secondary evolution usually gives the answer when some complications occur: delayed or non-union, AVN (which may occur within a few years after the initial trauma).

There are thus no specific preventive treatments for these complications and the restoration of an efficient local vascularization still depends, whatsoever the surgical technique used, on the delay between the initial trauma and the surgery (a worldwide consensus estimates this timeline inferior to 6-9 hours). If recent researches shows that Platelet Rich Plasma (PRP) or Stem Cells procedures (SC) could restore or protect the injured bone and improve the blood flow, there are some natural, but limited, opportunities for a spontaneous revascularization if the previous surgical conditions meet the standard described (medial epiphyseal vessels, lateral epiphyseal vessels, ligamentum Teres artery and retinacular art.) (Figure 9).

It's then rather easy to understand that we do not have much control on the amount of remaining blood flow in the injured femoral head : initial general status, age, trauma conditions and fracture specifications cannot be modified. This means that the remaining options to reduce the risk of complications is limited to the technique and the equipment used as well as the delay necessary to perform the surgery... Thus, the efficiency of the local emergency team which is asked to manage the patient within 6-9 hours after the injury requires trained practitioners and nurses, accustomed to such cases.



Figures 5: A-vascular necrosis.

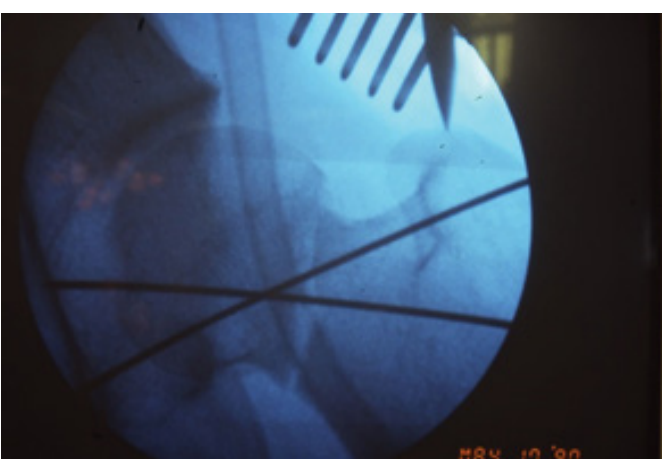


Figure 6: First case performed in Paris (France), 1990.

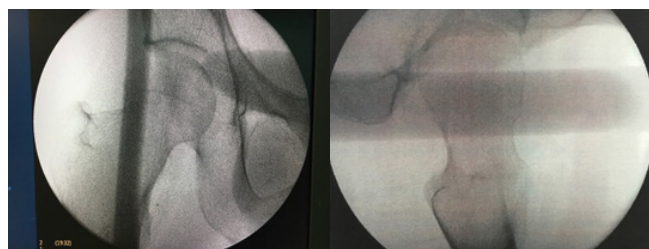


Figure 7: Reduction of a right sub-capital fracture.



Figure 8: K-wires insertion and gamma nail in place.



Figure 9: One year follow-up.

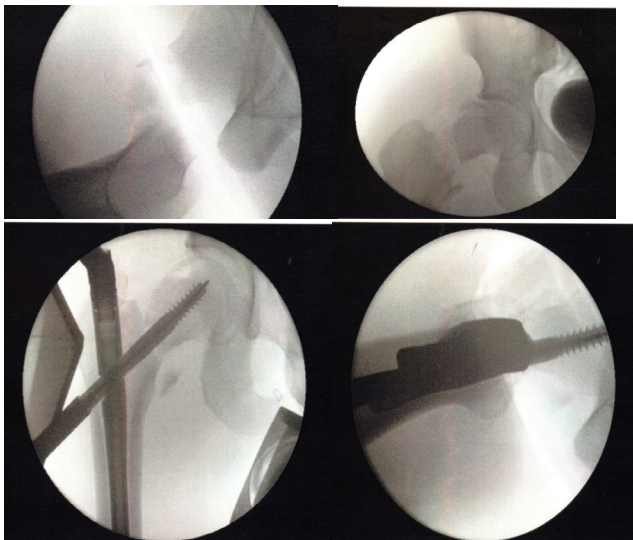


Figure 10: Severe right hip fracture in a 14 YO boy/ fracture G4-L2-PIPKIN.2 and fluoroscopy during surgery. Perfect post-operative result.

Whatever the general conditions to be treated before the surgery, whatever the gastric vacuity or current medications required, emergency specialists, anesthetists, orthopaedic surgeons should do their best to achieve the fracture's reduction – prior to the surgery – as fast as possible in this very short time delay and it is not as easy as we would like it to be: full check-up and initial explorations, vital parameters controlled and secured, initial skin traction or provisory immobilization (to avoid further displacements and supplementary vascular damages), fast and immediate treatment of other serious injuries, organization of the surgical time are difficult factors to manage in emergency but are the ones that should be shared by all the relevant personnel. This so requires a perfect cooperation and the best collaboration possible between all the professionals working in and around the emergency room and it is the only option to secure the best result possible and a lower complications rate (Figure 10).

Conclusion

Femoral cervical fractures are severe traumatism, especially for young adults and are often associated to other severe injuries. To

preserve or restore the femoral head blood flow and to avoid early or delayed complications (except possible new improvements from PRP or SC techniques) two factors may help: improving the surgical techniques and reducing the time delay before the surgery, which should be performed within 6-9 after the initial trauma. This needs a perfectly trained emergency team and a full cooperation between emergency specialists, orthopaedic surgeons and surgical staff.

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