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Recent Concept for Management of Femoral Neck Fracture Non-Union in Young Adults

***Mohamed Mansour Elzohairy**

Assistant professor of Orthopaedic surgery faculty of medicine, Zagazig University, Egypt

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***Corresponding author:** Mohamed Mansour Elzohairy, Assistant professor of Orthopaedic surgery faculty of medicine, Zagazig University, Egypt, Email: elzohairy.me@gmail.com

Introduction

Fractures of the neck of femur in young adults tend, unlike their counterparts in older people, to be a relatively higher-energy injury and require timely and meticulous diagnosis and management [1-4]. Anatomical reduction and stable internal fixation are essentials for achieving the goals of treatment in this young population allowing preservation of the femoral head while minimizing rates of non-union and osteonecrosis [1]. A delayed presentation of fracture of the femoral neck is one where there is a delay of 48 hours to 20 days between injury and diagnosis, whereas in a neglected fracture, this delay is in excess of 21 days [3]. While all femoral neck fractures are life-changing injuries, the neglected fracture in a young adult below the age of 60 years is one of the most challenging to treat and arguably has the most at stake [2]. The main complications of such injuries are a vascular necrosis (AVN) of the femoral head and non-union of the fracture with reported average incidences of 15% for AVN and 12% for non-union [2,3]. There are no clear guidelines for management of these fractures, although multiple methods have been used with varying success. In these individuals extreme force is required to produce fracture which explains the increased incidence of AVN & nonunion. In underdeveloped countries because of poverty, ignorance & lack of facilities these delayed presentation or nonunion is common [1-5]. The purpose of the current study is to assess treatment outcomes in adults with neglected femoral neck fractures, and propose a treatment protocol based on bone quality.

Anatomy

The blood supply of the femoral head comes from three main sources; the medial femoral circumflex artery (MFCA), lateral femoral circumflex artery (LFCA) and the obturator artery. In the adult, the obturator artery provides little and variable amount of blood supply to the femoral head via the ligamentous teres. The LFCA gives rise to the inferior metaphysical artery by way of the ascending branch and provides the majority of the infero-anterior femoral head. The largest contributor to the femoral head, especially the superolateral aspect of the femoral head is the MFCA. The lateral epiphyseal artery complex comes from the MFCA and courses along the posterosuperior aspect of the femoral neck before supplying the femoral head. It is important to know and understand that these terminal branches supplying the femoral head are intra capsular. Thus, disruption or distortion due to fracture displacement of terminal branches to the femoral head plays a significant role in the development of osteonecrosis. Variables that have been hypothesized in contributing to femoral head osteonecrosis include vascular damage from the initial femoral neck fracture, the quality of reduction or fixation of the fracture (restoring flow to the distorted arteries) and the elevated intra capsular pressure (Figure 1) [5].

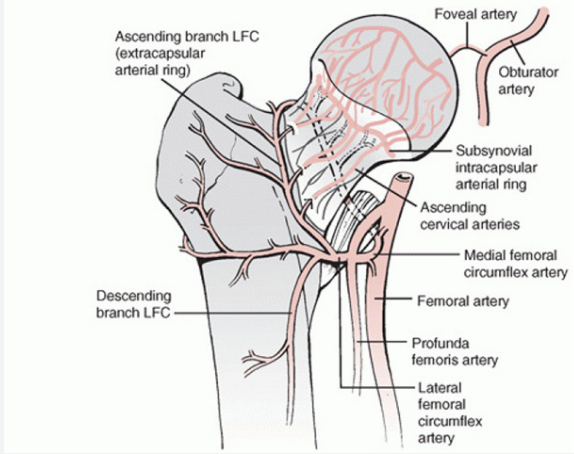

Figure 1: Blood supply of the neck of the femur.

Mechanism of Injury

Fractures of the femoral neck can occur following both direct and indirect mechanisms.

Indirect

The proximal femur remains fixed by the capsule and iliofemoral ligaments when the leg rotates externally during a

fall. The osteoporotic femoral neck buckles and fractures due to this abnormal stress.

Direct

In younger patients, these fractures occur as a result of a direct blow to the greater trochanter, which transmits an axial force to the femoral neck. In the elderly patients, femoral neck fractures usually occur as a result of a fall from standing height. Poor bone density, multiple medical problems and propensity to fall are major risk factors for femoral neck fracture. In young adults, the mechanism of injury is often high-energy trauma, such as motor vehicle accident or fall from height. Fractures that occur in this normal bone density population require substantial axial load with the hip in an abducted position [4-7].

Classification

Garden's classification [5]

Garden, in 1961, proposed a classification in which he divided sub capital fractures into four major types on the basis of the alignment of the trabecular in the femoral neck.

Pauwels' classification [1]

Pauwels observed that the obliquity of the fracture line with the horizontal plane significantly affected the prognosis of the fracture. The angle formed by extending the fracture line upwards to meet an imaginary horizontal line drawn through the trans tubercular (iliac crest) plane on AP film is described as 'Pauwels' angle'. The higher the value of this angle, the greater is the instability of the fracture (Figure 2).

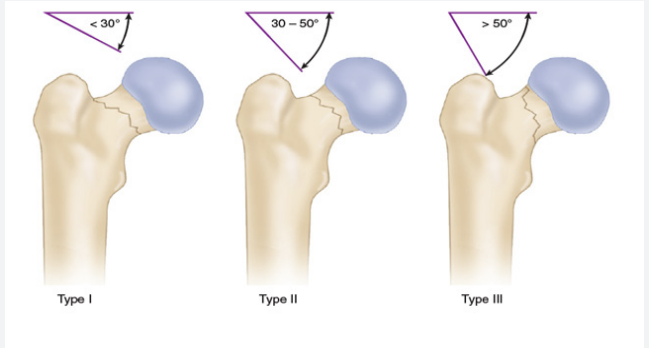

Figure 2: Pauwels' classification.

Type Pauwels' angle

I. Less than 30 degrees

II. Between 30 and 50 degrees

III. More than 50 degrees20.

Despite known limitations, femoral neck fractures in elderly patients are frequently described using the Garden classification. The Garden classification is not as useful for describing femoral neck fractures in young adults. Pauwels' classification might be more descriptive and useful because it is based on fracture pattern and is concerned for achieving a stable fixation in femoral neck fracture in the young population. Pauwels' classification is based on the angle of femoral neck fracture relative to the horizontal axis [1-8].

A. Leighton's Classification of Femoral Neck Non-union [9].

i. Type - Inadequate fixation or non-anatomic reduction.

ii. Type - Loss of fixation with fracture displacement

iii. Type - Fibrous non-union with no displacement and intact fixation

B. Sandhu et al. [10] Classification of Femoral Neck Non-union [10]: Grade I femoral neck nonunion (proximal fragment >2.5 cm, irregular fracture margin, fracture gap of <1 cm, and viable femoral head) has union rate of 100% followed by 89% in Grade II (proximal fragment >2.5 cm, smooth fracture margin, fracture gap between 1 and 2.5 cm, and viable femoral head) and 33% in Grade III (proximal fragment <2.5 cm, smooth fracture margin, fracture gap between >2.5 cm, and osteonecrotic femoral head) after (NFN) Go to fixation.

C. Why is non union common after fracture neck femur NOF?

i. Absence of cambium layer of periosteum of femoral neck leads to decrease in the healing potential (Phemister, 1939).

ii. Continuous Synovial bathing.

iii. Avascularity as healing callus comes from the neck shaft side the fracture because of avascularity of the head (Hulth 1961).

iv. High velocity trauma in young adults.

D. Factors contributing to nonunion of femoral neck

i. Inaccurate reduction.

ii. Unsound or loss of fixation.

iii. Vascular insufficiency.

iv. Posterior comminution.

v. No treatment.

E. Avascular Necrosis & Non union

i. Patients with normal bone stock have higher risk of AVN.

ii. A vascularity has a great bearing on the outcome of treatment.

iii. Quite a few non unions have a vascular heads but non union is not always a certainty in a vascular heads.

iv. Posterior comminution present in >60% of pts who later developed nonunion.

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v. No Treatment, untreated displaced fractures almost always will go for non union unless proved otherwise.

F. Management concepts: The goals of treatment are different for the elderly versus the young adults. In the elderly patient, the goals are mobility with weight bearing as tolerated and minimizing complications seen with prolonged bed-rest. Multiple surgical options are considered; reduction and internal fixation, hemiarthroplasty or total hip arthroplasty. Considerations include the patient's physiological age, level of activity, medical comorbidities and the degree of bone density [3,4-11].

G. Investigation

i. Plain X-rays.

ii. Bone Scanning.

iii. Tomography or high resolution CT scan.

iv. MRI.

H. Treatment: Although prosthetic replacement frequently is considered for the treatment of displaced fractures in elderly patients, efforts are focused on preserving the femoral head in physiologically younger patients. Surgical options are mainly divided into head salvage procedures & sacrificing procedures [5].

I. Salvage procedures: If femoral head is viable and adequate neck is remaining non unions can be treated by:

i. Fixation alone.

ii. Osteotomy+/-fixation.

iii. Muscle pedicle bone grafting+/-fixation.

iv. Cortical bone grafting+/-fixation.

v. Vasculaized fibular grafting.

vi. Cancellous bone grafting+/-fixation.

vii. Combination of osteotomy and bone grafting.

viii. Combination of Fixation with platelet rich plasma.

a. Fixation alone: Could be tried within 3 weeks of injury (late presenters or untreated fractures) which are undisplaced or are reducible. In established cases of non union will not suffice (Rocked & Green 1990).

b. Osteotomy+/-fixation: The following different types were reported in the literature;

i. Pauwel's osteotomy

ii. Dickson's geometric osteotomy

iii. McMurrey's osteotomy

iv. Schanz angulation osteotomy

a) Pauwel's osteotomy (1935): Mechanical problem then a biological one. Abduction osteotomy at intertrochanteric level Converts shearing force into compressive force it is based on Pauwel's classification. AVN without segmental collapse is NOT a contraindication". Marti et al. (1993) have reported 86% union in 50 nonunions.

b) Dickson's geometric osteotomy (1947) [12].

i. Indications: Nonunion with viable femoral neck & varus displacement.

ii. Advantages

a) Easy to perform

b) Immediate stability can be provided

c) Converts sheer force into compressive force

c) McMurrey's Osteotomy (1936) [13]

i. Biomechanics

I. Displacement type of osteotomy.

II. Puts the shaft beneath the head.

III. Line of weight bearing shifted medially.

ii. Disadvantages

I. Makes the fracture line horizontal.

II. Shortens the lever arm between the trochanter and the hip and leads to early OA changes

III. Makes future arthroplasty difficult

IV. Not practiced and no longer popular

iii. Schanz angulation osteotomy [14]

I. Made distal to lesser trochanter.

II. Angulated so as to gain length.

III. Line of weight bearing shifted medially.

IV. Not popular.

c. Muscle pedicle bone grafting+/- fixation: Useful in delayed presenters as well as non union.

I. Technique: Insertion Quadratus femoris muscle to the femur is mobilised with femoral cortex and is fixed across the fracture site posteriorly. Meyer et al. [15,16] have reported 90% union and 11% segmental collapse at 2 years

II. Muscle pedicle bone grafting (MPBG) +/- bone grafting: The gluteus minimus was used with attached bone block which was fixed anteriorly. This technique was used in proven nonunions with absorbed necks they obtained 75% good results. In another series, used screw fixation + MPBG they found 11% segmental collapse as compared to 32% with fixation alone in delayed presenters, [15-19].

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d. Cortical bone grafting +/- fixation: Nagi et al. [20] in their series the Paients. presenting as late as 10 months were included in the study. The Fibula was used as a strut graft+ single screw + BG then they put the patient in hip spica. They reported successfully 80% good results in late presenters. All bad results were in nonunions.

e. Cancellous grafting +/- fixation: Dickson [21], had promising results through window created anteriorly in the head and neck.

f. Sacrificing procedures: These included the following techniques

i. Unipolar arthroplasty.

ii. Bipolar arthroplasty.

iii. Total hip arthroplasty.

iv. Girdlestone arthroplasty.

v. Arthrodesis.

Decision Making

I. Late presentation

Irrespective of vascularity of the head, good reduction achieved and neck shaft angle maintained &

A. If presented within 3 weeks: Fix it.

B. If presented after 3 weeks up to 3 months: 1-Fixation +BG (Cortical). 2-Muscle pedicle bone grafting.

C. If presented after 3 months with shortening and varus of the head.

i. Pauwell's osteotomy+/- BG

ii. Dickson's geometric osteotomy

iii. If there is segmental collapse

iv. Replacement arthroplasty

v. Arthrodesis.

D. Confirmed Non unions: Young adults (20-40) (neck is not absorbed and the head is viable)

i. Fixation alone will not work.

ii. Augment it with BG or osteotomy or MPBG.

iii. Preserve the head as far as possible.

E. If neck is absorbed and the head is not viable

i. Arthrodesis

ii. Girdlestone arthroplasty

iii. Bipolar after proper explanation to the pt if acetabular cartilage good.

iv. THR if articular cartilage is of poor quality

F. Middle age group (40-60)

i. If head is viable and neck is not resorbed

ii. Fixation+ BG

iii. Osteotomy if leg is short

iv. If there is segmental collapse

G. Bipolar or THR

i. If no segmental collapse but evidence of AVN

ii. Pauwell's osteotomy

iii. MPBG

H. Surgical technique for joint preserving procedures: There have been many studies regarding the management of neglected femoral neck fractures in young adults. All aim at preserving the femoral head with hip arthroplasty being reserved as a salvage or secondary procedure. The treatment options tried have predominantly used internal fixation in conjunction with either osteotomy or bone grafting (vascularized or non-vascularized).

I. Combined Internal FixationWith Muscle-Pedicle Bone Grafting

a. Principle: Use of muscle pedicle bone graft as vascularized graft aiming for the revascularization of the head of the femur (Figures 3 & 4).

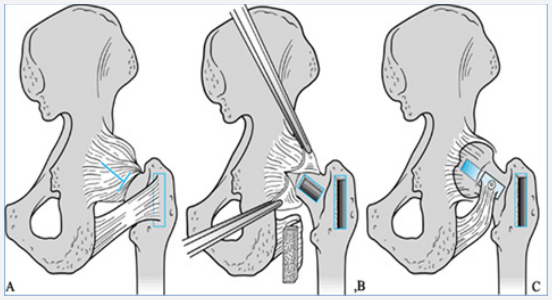

Figure 3: (A) Marking of the graft and site of incision of capsule. (B) inverted T shaped incision of the capsule, gutter made in the neck and harvested muscle pedicle graft (C) insertion of the graft and and fixation with screw.

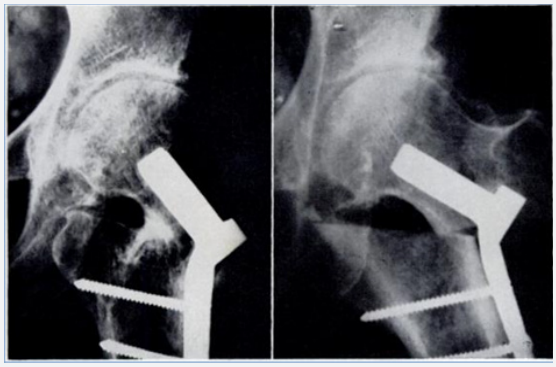

Figure 4: McMurray medial displacement osteeotomy.

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J. Modified Pauwels' Intertrochanteric Osteotomy

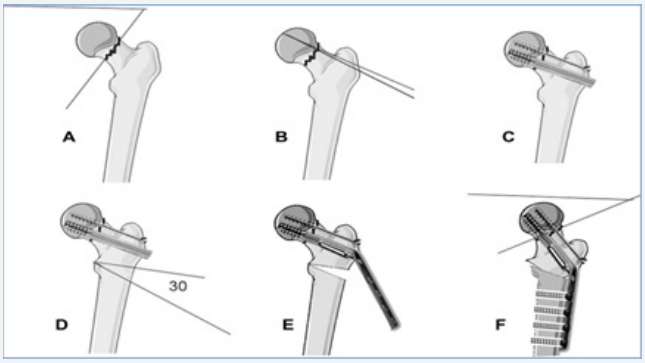

Figure 5: (A) Fracture after closed reduction. Note high Pauwels angle. (B) Two Kirschner wires are inserted for provisional fixation. (C) Antirotation screw (if needed). DHS lag screw inserted at an angle (105) (D) Two Kirschner wires with an angle of (30) between them are inserted to guide the saw blade. (E) The (30)wedge is removed and DHS side plate applied. (F) The side plate is screwed to the shaft closing the wedge and correcting the Pauwels angle.

i. Principle: The biomechanical principle behind Valgus osteotomy is that it converts shearing forces into compressive forces by changing the fracture inclination. Other authors use (DHS) for fixation instead of double angled blade plate (Figure 5).

ii. Triple attack technique for non-union of femoral neck fractures: The 'triple attack' procedure. This constituted iliac autogenous bone grafting, valgus subtrochanteric osteotomy together with static fixation across the non-union fracture site of the neck to avoid delayed femoral neck shortening.

K. Free fibular bone graft

i. Principle: The use of internal fixation and fibular auto grafting for neglected fractures for revascularization of the femoral head.

A. There are two types of free fibular graft exist

a. Vascularized free fibular bone grafting: Free vascularized fibular grafting has been reported to be successful for adult patients with osteonecrosis and non-union after fracture neck femur. But most of the studies that include Vascularized free fibular bone grafting did not match with the eligibility criteria of this meta-analysis (Figures 6 & 7).

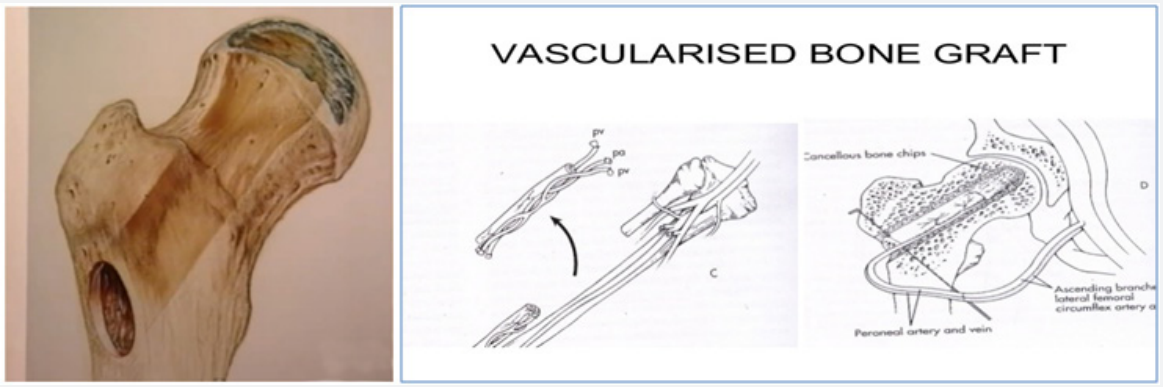

Figure 6: vascularized free fibular bone graft.

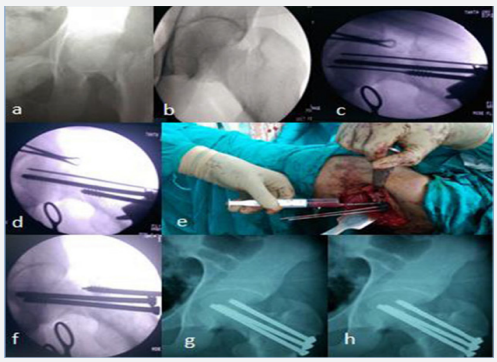

Figure 7: a) Surgical technique on a male patient, 28 years old, with transcervical fracture neck femur (Garden III). B) Post-reduction. C) Introduction of the screw till the fracture site. d, e) Withdrawal of the guide wire and injection of PRP. f The same was done for other screws. g Post-operative radiograph. h Follow up X-rays after ten weeks with complete union.

b. Non vascularized free fibular bone graft: Nagy et al reported good results with this technique.

Discussion

Haemodynamic studies of patients with a fractured neck femur have shown that the femoral head is usually in a relatively hypovolaemic state when compared with other bony tissue. Both the extra- and intraosseous blood supplies of the femoral head are susceptible to injury in these patients and the injury to the extraosseous vessels is proportional to the amount of displacement of the fracture [3]. Open reduction of a fracture through posterior approach risks damage to any remaining blood supply from the posterior retinacular vessels and the ascending branch of the medial circumflex femoral artery but this may nonetheless be a worthwhile risk. The valgus angulation osteotomy used to treat nonunion is usually performed in the subtrochanteric or intertrochanteric regions, and is more efficient than the displacement osteotomy in converting shearing forces

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at the fracture site into compressive ones and improving rates of union.[4] The biological basis of this is a presumed increase in blood flow and so AVN is not a contraindication for valgus osteotomy. The angulation osteotomy can also simultaneously correct rotational and limb length discrepancies. Fixation with a double-angle blade plate has largely been superseded by the use of dynamic compression screw implants.

These carry the advantages of widespread availability and familiarity to most orthopaedic surgeons as well as compression. Valgus osteotomy with fixation by double angle blade plate is a traditional method for the treatment of nonunion and for neglected fracture of femoral neck. Fixation by double angle blade plate is a technically demanding procedure and blade plate may displace the fracture fragments [5]. Dynamic compression screw, which is routinely used for intertrochanteric fractures, provides a technically simple means of fixation for valgus osteotomies in the treatment of femoral neck nonunion. An added advantage over blade plate DHS provides compression at the fracture site.

The biological advantage of valgus osteotomy is an increase in blood flow after osteotomy which increases the chances of union. Cut through and implant failure with blade plate are higher than DHS. While using blade plate, hammer impact can displace the fragments. In dynamic hip screw, no doubt the implant is not hammered, but the chances of rotation of head of femur are there around DHS reamer. Avascular necrosis without head collapse has not been considered to be contraindication for valgus osteotomy [3-5]. It is also well documented that revascularization of head is possible both by artery of ligamentum teres and by vessels crossing the uniting fracture at the fracture site. Osteotomy is commonly associated with two problems; a decreased range of movement and non-union of the osteotomy itself.

A technique employing muscle pedicle bone grafting with rigid internal fixation has been advocated to prevent non-union and AVN of the femoral head. Drilling of the femoral head decompresses the necrotic bone and encourages the growth of vascular granulation tissue while the muscle graft itself acts as a vascular graft, encouraging bone growth and revascularization of the femoral head. A cortical graft also carries certain advantages. The fibula is easy to harvest and carries minimal risk of morbidity at the donor site. It offers both biological and structural function and may be used as a nonvascularised strut graft to give a dependable and technically less demanding graft. Fixation with three cancellous screws provides firm fixation, while parallel lag screws permit collapse whilst maintaining position [3-5].

The shape of the fibula stabilises the fracture by preventing rotation, and holes drilled in its surface may promote bony ingrowth. The subchondral placement of the bone in a vascular femoral heads may minimize structural collapse until revascularisation takes place [20]. When vascularised fibular grafts are examined in the literature, most publications are case reports of one or two cases and hence did not meet the inclusion criteria for the current study and unfit for meta-analysis due to the lack of paired comparison and statistical analysis. While the results are encouraging, low numbers preclude a confident analysis of outcomes. Successful fracture healing requires mechanical stability and a viable biologic microenvironment. Fractures with compromised biology will benefit from treatment options that can augment the biologic potential at the site of bone repair. An ideal bone graft should be osteoinductive, osteoconductive, osteogenic, angiogenic and should provide mechanical support and promote physiologic healing without any significant adverse effects [15-22]. Regenerative strategies like the use of bone morphogenic proteins, platelet rich plasma, stem cells and anabolic agents are promising in the treatment of fractures either acute or fracture non-union. Most recently Samy [22] had reported the efficacy of the use of platelet rich plasma (PRP) in management of femoral neck fractures.

In his prospective study that was conducted between on a total of 60 patients who were included in the study and categorized randomly into two groups. Group A included fracture neck femur treated by closed reduction and internal fixation with three cannulated screws and group B by addition of PRP to internal fixation. The author, planned to compare time of healing, need for revision and incidence of complications between the two groups. The results of this study generally showed that both the median clinical and radiographic healing time were lower in group B compared to group A. All of the Sacrificing procedures have its merits and demerits. The problem in young people is that, they are high demand group so the function and the prolonged biomechanical loads over the hip could be over estimated as regarding the longevity and the durability of either the procedure done or the inserted implant. In the future with reported excellent data in the literature as regarding increased both longevity and durability of cementless ceramic on ceramic hip prosthesis this may be change the strategy of decision making in salvage procedure for young people group with absorbed femoral neck and non viable femoral head.

Conclusion

In published results to date, there is clear superiority of osteotomy with internal fixation over other methods by virtue of superior rates of union and reduced levels of a vascular necrosis. The relatively low morbidity compared with other methods requiring bone grafting or soft tissue transfer suggests that this is the treatment of choice.

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