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Original Article

Management of Intracapsular Femoral Neck Fractures in Adults Younger Than 65 Years
治療六十五歲以下之成年人關節囊內股骨頸骨折之研究

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ABSTRACT

Purpose: The study is to review the results of intracapsular femoral neck fractures in young adults (age < 65) treated with reduction and multiple-screw fixation from 2000 to 2007.
Method: Sixty-four consecutive patients were reviewed retrospectively. The mean age of the patients at the time of injury was 53.5 (32–65) years old. All fractures were either closely or openly reduced and fixed with three 7.5-mm cancellous screws. The mean follow up period was 36.8 months (6–100).
Results: We found that 9 of 64 (14.1%) patients developed osteonecrosis of femoral head on follow up. Displacement of fracture (Garden classification), initial stability of fracture pattern (Pauwel classification), and quality of reduction (Haidukewych grading) were found to have significant effect on the development of osteonecrosis, whereas the effect of patient age, time lapse of surgery, capsulotomy, hip aspiration, and postoperative weight bearing regimen were not statistically significant.
Conclusion: Fracture pattern and quality of reduction govern the fate of the femoral heads in young adults with their intracapsular femoral neck fractures fixed with screws.

中 文 摘 要

這研究回顧了由2000年至2006年，所有在本院小於65歲患有關節囊內股骨頸骨折的成年病人接受了復位及多枚螺絲固定手術，共有連貫的64位病人被歸納在這個回顧性的調查。該組病人在受傷時的平均年齡為53.5歲。所有骨折經封閉式或開放式復位後，再以3枚7.5mm螺絲固定。病人的平均跟進期為36.8個月。64位病人中有9人出現股骨頭壞死。骨折移位（Garden 分類法）、骨折形態的穩定性（Pauwel 分類法）及復位的質量（Haidukewych 分類法）對股骨頭壞死的出現有顯著的影響。可是病人的年齡、手術的延時性、關節囊切開術、髖關節抽吸及術後負重活動方式均對股骨頭壞死的出現在統計學上無顯著差異。

Introduction

Geriatric hip fracture is a common orthopaedic problem. Hip fractures, particularly femoral neck fractures, do occur in young adults. Intracapsular femoral neck fracture is frequently associated with osteonecrosis of the femoral head once the precarious blood supply is disrupted. It could then lead to the collapse of the femoral head and the development of secondary osteoarthritis of the hip joint.[1,2] If it happens, it significantly affects patient's ability to work and hence quality of life. Prosthetic replacement, for example, hemiarthroplasty or total hip arthroplasty could be a good choice of remedial treatment for elderly patients but not young adults and therefore it is more logical to preserve the femoral heads in the young. Various techniques had been discussed to maintain the viability of femoral heads, including earlier surgical intervention, decompression of hip joint, and good quality of fracture reduction. Indeed, surgical outcomes that followed those recommendations were still controversial.[3]

The purpose of the study is to review the outcome of intracapsular femoral neck fractures in our hospital and to identify factors that lead to or prevent osteonecrosis in adult patients younger than 65 years.

Methods

From 2000 to 2007, adult patients of 65 years or younger who sustained intracapsular femoral neck fractures and received

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internal fixation in a single centre were reviewed. Intracapsular femoral neck fracture was defined as either a transcervical fracture (Type 31B2) or a subcapital fracture (Type 31B1) according to the system of the Orthopaedic Trauma Association.[4] Basicervical fractures (Type 31B2.1) were not included in the study as they were generally accepted that they had relatively low risk of disturbing the blood supply to the femoral head and thus future osteonecrosis. Fracture displacement is defined according to Garden classification as nondisplaced (Garden I or II) or displaced (Garden III or IV).[5] Apart from displacement, fracture pattern is also considered important in describing femoral neck fractures in young adults, as in the Pauwels classification.[6] It described the orientation of the fracture line, which is related to the relative stability of the fracture. A femoral neck fracture line that is less than 30° to the horizontal plane is considered as Pauwels I, one with an angle between 30° and 50° as Pauwels II, and one with an angle more than 50° as Pauwels III. Pauwels III fractures were considered as unstable fractures and had higher chances of osteonecrosis, implant failure, malunion, and nonunion.[6]

Sixteen patients of those who had received either hip replacement (hemi- or total) as primary treatment or conservative treatment were excluded from the study. Clinical records and radiological reports were reviewed; preoperative or postoperative radiographs of the injured hips (anteroposterior and cross-table lateral views) were examined. Documentation of the time of injury, operative details on the injured hips, including method of reduction, and decompression of hip joint were recorded. Quality of reduction of fracture and occurrence of osteonecrosis or nonunion were cross-examined by two of the authors independently. Grading of the fracture reduction was based on residual angulation and displacement of fracture according to Haidukewych et al.[7] It is considered as excellent (<2 mm of displacement and <5°in any plane), good (2–5 mm displacement and/or 5°–10° of angulation), fair (>5–10 mm of displacement and/or >10°–20° of angulation), or poor (>10 mm of displacement and/or >20° of angulation). Osteonecrosis was classified according to Ficat.[8] Ficat stage I osteonecrosis was diagnosed either by magnetic resonance imaging or bone scintigraphy. More advanced stages could be diagnosed by plain radiographs of hips. Functional outcomes, including pain perceived and the ambulatory status, were noted.

Analyses were performed using the SPSS 13.0 as the platform (SPSS Inc., Chicago, IL, USA). χ^2 test and independent simple *t* test were adopted using 95% of confidence interval. A binary logistic regression model was used to study the effect of age, fracture displacement, unstable fracture pattern (i.e. Pauwels III fracture), hip joint decompression, quality of reduction of fracture, and time of surgery to the development of osteonecrosis. Twelve hour between the time of injury and operation was arbitrarily used as the cutoff point to stratify patients into two groups.[2,9,10] The survivorship of cases who were free from revision surgery related to osteonecrosis, nonunion, or both was analysed using the Kaplan-Meier model.

All patients were first medically stabilized before the operations. They were put on a radiolucent fracture table in supine position. For undisplaced fractures, no traction would be applied. For displaced fracture, closed manipulation would be performed first with the hip flexed at about 45°, then abducting the hip and finally extending and internally rotating the limb. A longitudinal incision will be made on the lateral aspect of the proximal femur. The tensor fascia lata was incised. The vastus lateralis will be reflected anteriorly. Three guide pins will be inserted under fluoroscopic guidance. All fractures were fixed with three 7.5 mm half-threaded cannulated screws. In case of suboptimal reduction after closed manoeuvre, open reduction will be proceeded. We preferred anterolateral approach (Watson-Jones) by extending incision proximally and anteriorly. A T-capsulotomy was made to decompress the intracapsular haematoma and to facilitate the reduction. A Schanz pin would be used to control the distal fragment and reduction was achieved under direct visualization. Again, three cannulated screws were used for fixation. Wound was closed in layers without drain. For undisplaced fractures, patients were advised to have full weight bearing on the operated limb as tolerated as soon as they could mobilise after the operation. For displaced fracture group, they are advised to have touchdown walking either with crutches or walker in the first 6 weeks and then partial weight bearing walking for the next 6 weeks.

Results

Seventy-one patients with 74 fractures were retrieved. There were 31 males and 40 females. Two patients returned to their home countries soon after the operations were excluded. Eight patients were lost to follow-up after the primary surgery. Therefore, 64 fractures were available for follow-up (Table 1).

Among those 64 fractures, the patients' mean age at the injury were 53.5 years (32.0–65.0, median 55.0). Eighteen patients had their injuries happened at work place. Five patients suffered from high-energy trauma. Two patients had multiple injuries, including one with fracture neck of humerus, one with multiple-rib fractures plus a pelvic fracture. The mean follow-up time was 36.8 months (6–100, median 28).

Fracture pattern, perioperative details, and rehabilitation

Twenty-six fractures (40.6%) were displaced and 38 fractures (59.4%) were nondisplaced (Table 2). Among the displaced fractures, 12 of them (46.2%) had their operation performed with 12 hours of injury.

Six fractures (9.4%) were regarded as Pauwels III and were all displaced on initial presentation. Thirty-eight fractures (59.4%) received internal fixation of fracture *in situ*, 24 (37.5%) required closed reduction, and 2 fractures (3.1%) required open reduction to achieve satisfactory alignment of fractures.

Twenty-four fractures (37.5%) had concomitant anterior capsulotomy performed as a means of decompression of intracapsular haematoma. One fracture had redisplacement noted 3 days after the primary surgery with revision internal fixation performed. It went into an uncomplicated union.

Forty-three fractures (67.2%) were considered to have excellent reduction in the initial postoperative radiographs, including those

Table 1
Demographic data

Data on patients (overall)	
Number of fractures	64
Mean age (y)	53.5 (32–65)
Mean duration of follow up (mo)	36.8 (6–100)
Fracture type	
Undisplaced (Garden I, II), *n* (%)	38 (59.4)
Displaced (Garden III, IV), *n* (%)	26 (40.6)
Fracture pattern	
Stable (Pauwel I, II), *n* (%)	58 (90.6)
Unstable (Pauwel III), *n* (%)	6 (9.4)
Fracture reduction	
Excellent, *n* (%)	43 (67.2)
Union rate after one operation, *n* (%)	62 (96.9)
Rate of osteonecrosis, *n* (%)	9 (14.1)
Rate of conversion to total hip arthroplasty, *n* (%)	3 (4.69)

Table 2
Summaries of demographic distribution, fracture pattern, and outcomes between displaced and nondisplaced fracture group

Parameters	Displaced fractures ($n=26$)	Nondisplaced fractures ($n=38$)	p
Sex			
Male	20 (76.9)	9 (23.7)	<0.001
Female	6 (23.1)	29 (76.3)	
Age (mean)	53.0	53.9	>0.05
Work-related injury	11 (42.3)	7 (18.4)	0.03
Occupation			
Retired/unemployed	10 (38.5)	26 (68.4)	>0.05
Sedentary	2 (7.7)	2 (5.3)	
Medium work	10 (38.5)	8 (21.1)	
Manual work	4 (15.4)	2 (5.3)	
Pauwel's type III fractures	6 (23.1)	0	0.002
Postoperative weight-bearing			
Nonweight	14 (53.8)	12 (31.6)	>0.05
Touchdown walking	2 (7.7)	3 (7.9)	
Partial weight bearing	9 (34.6)	14 (36.8)	
Weight-bearing as tolerated/full-weight	1 (3.8)	9 (23.7)	
Quality of reduction			
Excellent	7 (26.9)	36 (94.7)	<0.001
Good	14 (53.8)	2 (5.3)	
Fair	4 (15.4)	0	
Poor	1 (3.8)	0	
Osteonecrosis	8 (30.8)	1 (2.6)	0.001
Ficat I	2 (7.7)	0	
Ficat II	0	1 (2.6)	
Ficat III	5 (19.2)	0	
Ficat IV	3 (11.5)	0	
Revision surgery required	6 (23.1)	1 (2.6)	0.01
Ambulatory status in latest follow-up			
No aids needed	14 (53.8)	32 (84.2)	0.028
One cane	3 (11.5)	2 (5.3)	
Quadripod	3 (11.5)	2 (5.3)	
Crutches	5 (19.2)	0	
Wheelchair-bound	1 (3.8)	2 (5.3)	
Pain			
No pain	10 (38.5)	20 (52.6)	0.002
Moderate pain with no problem with ADL	7 (26.9)	17 (44.7)	
Moderate pain affecting ADL	9 (34.6)	1 (2.6)	

Data are presented as n or n (%). ADL = activities of daily living.

nondisplaced fractures, which were fixed with screws *in situ*. For the displaced fractures, excellent and good reduction could only be achieved in 26.9% and 53.8% fractures, respectively.

Nine fractures (14.1%) were diagnosed to have osteonecrosis (Ficat classification): two (3.1%) are Stage I, one (1.6%) Stage II, five (7.8%) Stage III, and one (1.6%) Stage IV. Eight cases (88.9%) of osteonecrosis were from the displaced fracture group. Among the eight cases of osteonecrosis, 5 of 12 cases (41.7%) developed osteonecrosis when the fracture was fixed within 12 hour of injury, whereas 3 of 14 cases (21.4%) developed osteonecrosis if it was fixed more than 12 hours postinjury. It was found to be not statistically significant (given p value here). There was only one case of nondisplaced group developed osteonecrosis (2.6%).

For those cases with osteonecrosis, three were converted to total hip arthroplasty, one received a valgus-osteotomy of the proximal femur to unload the affected portion of femoral head, one had removal of screws only, and one refused conversion of total hip arthroplasty although it was symptomatic. Three fractures were associated with no or mild discomfort and were treated expectantly.

In the analysis, binary logistic regression model suggested that displaced fractures (according to Garden classification), Pauwels III orientation, and quality of reduction were the significant factors ($p=0.001$, 0.008, and 0.02, respectively) in association with the occurrence of osteonecrosis. If the effect of fracture displacements was eliminated using the forward-stepwise model, however, Pauwels III orientation and quality of reduction would become insignificant. Other factors, such as anterior capsulotomy, age, and time of surgery, were also not statistically significant in our series.

There were two cases of nonunion (3.1%). Both fractures were displaced at initial presentation. Radiographic review of both cases revealed satisfactory reduction of fractures and proper screws placement. In one case, redisplacement of fracture was noted at 3 months after the primary surgery. The patient was an active intravenous drug abuser. Revision fixation was considered unlikely to succeed because of the delayed presentation, conversion to total hip arthroplasty was not contemplated, and the patient refused girdle stone procedure. Removal of screws was performed and the fracture went into nonunion, although no radiographic evidence of avascular necrosis was noted later on. The other patient turned up at about 3 years after the primary surgery and radiographs showed evidence of both nonunion and osteonecrosis of the femoral head, with cut-out of screw-tip at the superolateral portion of the femoral head. A Girdlestone operation was performed for this patient. Bacteriological examination was negative in both cases.

Overall, 54 fractures (84.4%) achieved union without radiological evidence of osteonecrosis. The survivorship of hips that were free from revision surgery (i.e. conversion to total hip replacement, removal of screws, and other salvage procedures) related to osteonecrosis, nonunion, or both was 61.2% (95% confidence interval: 49.8–72.6) in displaced group and was 95.6% (87.3–103.9) in nondisplaced group (Figure 1). Patients of displaced fracture group demonstrated inferior functional outcome in terms of postoperative ambulatory status and pain perceived (Table 2).

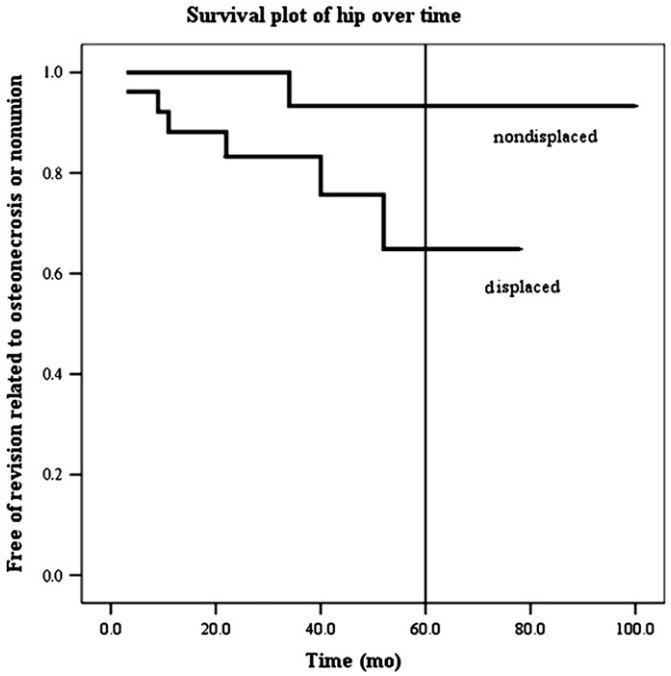

Figure 1. Survivorship of hips those were free from revision surgery related to osteonecrosis or nonunion over time (time line at 5 years).

Discussion

In this retrospective review, it demonstrated that the contemporary surgical treatment had yielded successful outcome for the management of young intracapsular femoral neck fracture, as reflected by low incidence of nonunion (3.1%) and osteonecrosis (14.1%), which were comparable with other series (e.g. Jain et al[9] 15.7% and Upadhyay et al[10] 16.3%).[1,2,6,9,10]

Various techniques and recommendations were introduced to prevent osteonecrosis. Studies had focused on those measures, including earlier fixation, anterior capsulotomy, or even the use of prednisolone. From our logistic regression analysis, however, the main determinant of the development of osteonecrosis was still displacement of fracture only.

Jain et al[9] suggested that operation within 12 hour of injury could reduce the chance of osteonecrosis. However, it could not be converted to better functional outcomes between early and delayed fixation groups. Dichotomized results were also noted in other studies. Swiontkowski et al[2] recommended that treatment within 8 hours of injury can decrease the rate of femoral head osteonecrosis. However, a randomised prospective trial by Upadhyay et al[10] had shown that a delay of more than 48 hours before surgery did not influence the rate of union or the development of osteonecrosis.

The nature of retrospective analysis had posted a possible selection bias in our studies, as the decision of performing a hip decompression rested on the operating surgeon. Harper et al[11] suggested that decompression of fracture haematoma by hip aspiration could reduce intraosseous pressure and increase pulse perfusion pressure, which probably improve the continuation of blood supply to the femoral head. It remains a controversial topic and is not supported by other studies. Maruenda et al[12] found that most patients who suffered from osteonecrosis following femoral neck fracture had the intracapsular pressure less than the diastolic pressure. In our series, we found that decompression of fracture haematoma had no significant benefits. We postulate that this effect had been outweighed by another dominating factor, that is, initial fracture displacement that had caused vascular insult at the time of injury.

The shortcomings of our studies included retrospective methodology, small number of cases, involvement of multiple surgeons, limited time of follow-up, and optional capsulotomy during the period of studies. In our series, only eight patients were diagnosed to have osteonecrosis, this significantly decreases the power of the study. In conclusion, internal fixation of intracapsular femoral neck fracture in adults younger than 65 years yielded successful outcomes in terms of fracture union and survivorship of the femoral head. Displaced fractures (Garden III & IV), Pauwels III orientation and quality of reduction (Haidukewych grading) were the significant factors in association with the occurrence of osteonecrosis. Among them, initial fracture displacement is the most important prognostic predictor. Benefit can neither be demonstrated in this series by performing the surgery within 12 hours from the injury nor by performing decompression of the joint capsule. Despite the fate of the femoral head is seemingly predetermined at the time of injury, we still advocate endeavouring to obtain good quality of reduction (excellent Haidukewych grading). Further study can be conducted to evaluate whether more liberal performing of open reduction can lead us to better outcome in managing displaced femoral neck fracture in young patients.

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