

## Fixation of intracapsular femoral neck fractures: Effect of trans-osseous capsular decompression

### *Femur boynu kırıklarının kapsül içi fiksasyonu: Kemik içinden kapsül dekompresyonunun etkisi*

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#### ABSTRACT

**Objectives:** Intracapsular femoral neck fractures have been found as associated with hemarthrosis. The fluid in the intact capsule elevates the intracapsular pressure to a level could tamponades the vascular supply of the femoral head. Therefore, capsular decompression seems necessary to salvage the femoral head circulation. Negative impact of the capsular incision also has been reported. Therefore, we hypothesize that creation of a trans-osseous portal can decompress the capsule as well as not threaten the capsular related blood vessels.

**Materials and methods:** In present study, 27 patients with intracapsular femoral neck fractures were included. Coinciding with closed reduction and internal fixation we made a trans-osseous portal for capsular decompression. Patients were followed-up prospectively for a mean period of 43.1 months.

**Results:** All fractures united. However, one patient 17 years-old who was nursed preoperatively in skin traction developed osteonecrosis of the femoral head.

**Conclusion:** Our results supported that the trans-osseous capsular decompression has evacuated the intracapsular haematoma and has not threatened the capsular integrity. Preoperative traction of the injured limb particularly in the young patient may play a role in development of osteonecrosis of the femoral head.

**Key words:** Femoral neck, intracapsular pressure, trans-osseous capsular decompression, traction, osteonecrosis, avascular necrosis

#### INTRODUCTION

Nonunion and osteonecrosis of the femoral head are the major complications of the intracapsular femoral neck fractures<sup>1</sup>. These complications are mainly caused by damage to the retinacular vessel at the

#### ÖZET

**Amaç:** Kapsül içi femur boynu kırıkları hemartrozla birlikte bulunmuştur. Sağlam kapsüldeki sıvı kapsül içi basıncı femur başı kanlanması önleyecek seviyelere yükseltir. Femur başı dolaşımını korumak amacıyla kapsül dekompresyonu gerekli görülmektedir. Bu nedenle kemik içinden bir yol açarak hem kapsül içi basıncı azaltmak hem de kapsül ilişkili kan damarlarını zedelemeyecek bir yöntemi ileri sürüyoruz.

**Yöntemler:** Bu sunulan çalışmada kapsül içi femur boynu kırığı olan ve kapalı redüksiyon ve internal sabitleme yapılan 27 hasta çalışmaya alındı. Kemik içinden bir yol oluşturup kapsül içi dekompresyon yapıldı. Hastalar ortalama 43.1 ay süreyle izlendi.

**Bulgular:** Tüm kırıklar iyileşti. Ancak operasyon öncesi cilt traksiyonu uygulanan 17 yaşındaki hastada femur başı osteonekrozu gelişti.

**Sonuç:** Sonuçlarımız kemik içinden kapsül dekompresyonu yapılmasının intrakapsüler hematoma boşalmasına yol açarak kapsül bütünlüğünü koruduğunu göstermektedir. Genç bir hastada operasyon öncesi kırık bulunan ekstermiteye traksiyon uygulanması femur başında osteonekroz gelişimine yol açmış olabilir.

**Anahtar kelimeler:** Femur boynu, kapsül içi basınç, kemik yoluyla kapsül dekompresyonu, çekme, osteonekroz, avasküler nekroz

time of fracture or, mostly by tamponade effect of an intracapsular haematoma<sup>1-5</sup>. The concerned authors pointed out that the intracapsular pressures are higher in non-displaced fractures than in displaced fractures that is because the capsule is probably intact<sup>1,3,4</sup>.

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The concept of capsular decompression may improve the blood supply of the femoral head remains a controversial point. Those refused that mentioned concept have built their suggestion on the results of the capsulotomy<sup>6,7</sup>. Theoretically, the common anterior capsulotomy can decrease the intracapsular pressure, but it does not increase the blood supply to the femoral head. Because incising the capsule may damage the anterior vessels<sup>2,6,7</sup>.

We hypothesize that making a trans-osseous portal for capsular decompression can reduce the intracapsular pressure, as well as does not threaten the capsular related blood vessels.

The aim of this study was to present the technique and its outcome as a salvage procedure for internal fixation of the intracapsular femoral neck fractures.

## PATIENTS AND METHODS

Between December 2004 and December 2007, 27 patients who agreed to participate in this prospective study, were included and managed for intracapsular fracture of the femoral neck. The local Ethics Committee approved the study protocol.

The fracture patterns were determined radiographically according to the Garden classification system<sup>8</sup>. We included patients with Garden grade I, II and III femoral neck fractures. Patients with the Garden grade IV fracture were not included due to high possibility of the capsular tear<sup>1,4</sup>.

Preoperative details of the included patients are listed in Table 1. Their mean age at the operation time was 47.8 years (range: 16-76). The mean time lag before surgery was 3.7 days (range: 1-6).

During the preoperative period, patients were allowed to place the injured limb in the most comfortable position i.e flexion and external rotation. Splint or traction of the injured limb were not performed, however, one patient who transferred from other hospital with injured limb in the skin traction.

## Operative Technique

Under spinal or general anesthesia, a closed reduction was performed. The fractures were fixed using the three cannulated cancellous screws or the dynamic hip screw with derotation screw (DHS/DRS) composite through the lateral exposure of the hip.

## Trans-osseous capsular decompression

After fracture fixation, under an image intensifier control, we inserted a Kirschner wire through the lateral cortex of the femur just anterior to the superior screw. To avoid long progress through the neck, the angle of entry should be perpendicular to the lateral cortex of the femur with forward inclination, slightly, greater than that of the neck anteversion. When the K wire peeping from the anterior cortex of the femoral neck (Figure 1-B), the advancement is stopped. Then a cannulated drill bite of 4.5 mm diameter was carefully introduced onto the K wire to just penetrate the cortices. The wire is manually removed leaving the drill bite in its place. A gush of a viscid blood was observed extruded through the canal of the drill bit. The drill bit is removed; the limb is internally rotated gently to squeeze the capsule. However, we have noticed a minimal amount of blood extruded without spurt when the surgery was delayed for three days or more.

## Follow-up

The patients were allowed active assisted mobilization of the hip as soon as pain allowed. Walking was allowed using crutches and toe touching until absence of pain and a solid union had been observed radiographically. Then, progressive weight bearing was started. However, if the reduction was considered as unsatisfactory, partial weight bearing was allowed only when the callus bridged the fracture gap.

Follow-up reviews were undertaken at three-weekly interval to occurrence of solid union. After union, patients were followed up at six-monthly intervals in order to assess the incidence of avascular necrosis<sup>7</sup>. The most recent examinations were performed at a median of 43.1 months (range: 24-60) postoperatively.

## Radiological Assessment

Reduction was assessed by combining the Garden alignment index<sup>8</sup> and the criteria of Lagerby et al<sup>9</sup>. Depending upon the quality of the reduction in antero-posterior (A-P) and lateral views, the patients were graded into one of three groups as follows: grade I, satisfactory reduction on both A-P and lateral views; grade II, unsatisfactory reduction on either A-P or lateral view; and grade III, unsatisfactory reduction on both A-P and lateral views<sup>7</sup>.

Placement of the screws was evaluated on the A-P and lateral views taken immediately postoperative. It was considered to be inappropriate if the screws either crossed each other at an angle of more than  $10^\circ$  or if they were in convergence of greater than  $10^\circ$ . If the placement was parallel or at an angle of less than  $10^\circ$  to each other, it was considered to be appropriate<sup>7</sup>. Parallelism between the screws of the DHS/DRS composite is deemed appropriate and used as an indicator for maintenance of reduction. In the subsequent radiographs, lost parallelism (Figure 1-E) indicated lost reduction<sup>10</sup>. In the A-P view, a distance of less than 0.5 cm between the screws of the DHS/DRS composite is deemed inappropriate. Screws penetrations of the femoral head, were considered inappropriate (Figure 2-C).

The time to osseous union of the fracture was estimated from date of the operation to occurrence of solid union. Solid union was defined as the mature bone seen to cross the fracture on the anteroposterior and lateral radiographs<sup>11</sup>. Nonunion was defined as failure of fixation with implant breakage or sclerosis of the margins of the fracture, persistence of or an increase in the fracture gap at one year after surgery<sup>7,11</sup>. Avascular necrosis was defined as appearance of subchondral sclerosis or the presence of segmental collapse<sup>7</sup>.

At the final visit, the femoral neck-shaft angle was measured in the A-P radiograph. If the neck-shaft angle was  $>130^\circ$ , it was considered acceptable, varus angulation was considered unsatisfactory result.

### Clinical assessment

Hip joint motion was measured using a goniometer and compared to the healthy side. Leg length was assessed clinically on both sides by measuring the distance between the anterior superior iliac spine and the tip of the medial malleolus<sup>12</sup>. At final follow-up, patients were evaluated functionally according to the criteria of the Harris hip score<sup>13</sup>.

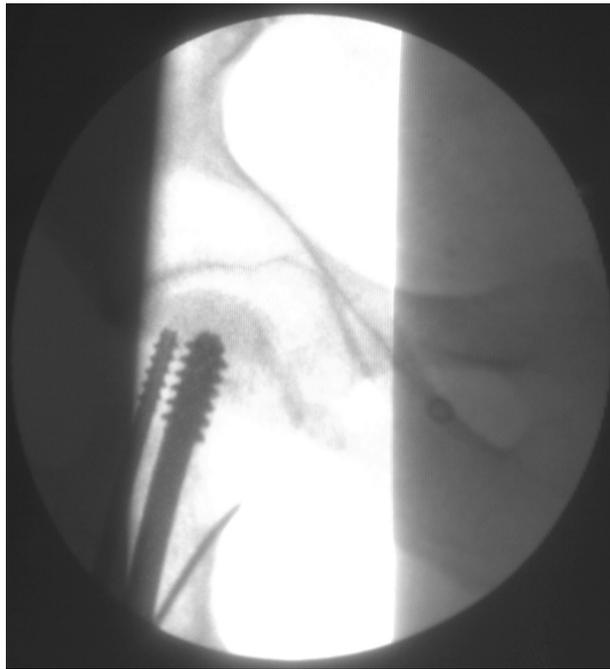
## RESULTS

Internal fixation achieved using the three cancellous cannulated screws in 20 patients (74.07%) and the DHS/DRS composite in seven patients (25.93%). On the immediate postoperative radiograph all patients were graded as a grade-I reduction. The pat-

tern of screw placement was proper in 22 patients (81.50%) and in 5 patients (18.50%) was improper (Table 1). The placement has been considered improper because the distance between the screws of the DHS/DRS composite is less than 0.5 cm in two patients and the cancellous screws crossed each other at an angle of more than  $10^\circ$  in two patients. In the fifth patient, the cancellous screws crossed each other and penetrated the femoral head (Figure 2-B and 2-C). Of the 5 patients with improper placement of the screws, one had loss of reduction at two months (Figure 1-C through 1-E) and one has exposed to second operation for removal of the screws (Figure 2-B through 2-D), however no complications have been reported in the rest of the 5 patients.



**Figure 1-A.** Preoperative A-P radiograph of hip joint of 33-years-old man with a Garden grade II fracture of the right femur



**Figure 1-B.** A photo was taken intraoperatively from the screen of the image intensifier shows the K-wire peeping from the cortex of the femoral neck antero-inferior to the screws of the DHS/DRS composite



**Figure 1-C.** Immediate postoperative radiograph shows good reduction of the fracture however, the distance that separates the screws of the DHS/DRS composite is less than 0.5 cm

At the most recent examination the femoral neck-shaft angle was  $>130^\circ$  in 26 patients (96.30 %) and one patient (3.70%) reported varus angle (Figure 1-F).

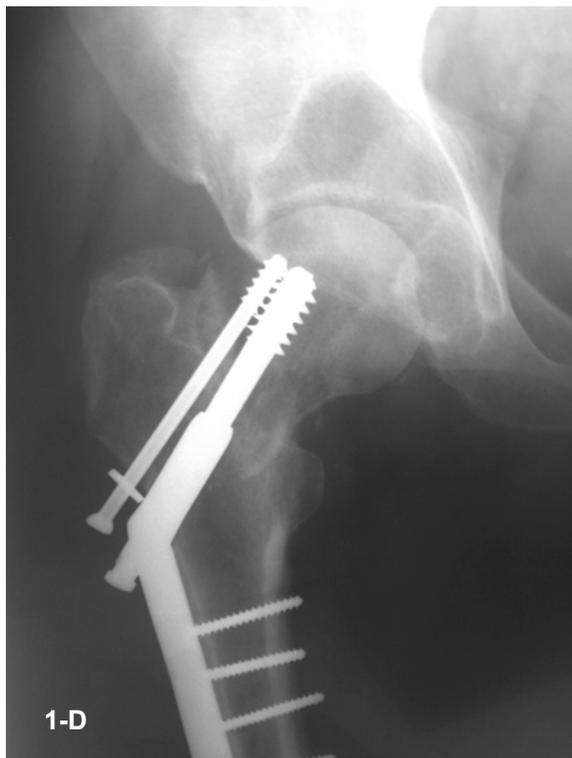
All fractures united within an average period of 11.8 weeks (Range: 8–20); the nonunion has not been reported (Table 1).

**Table 1.** Preoperative data and postoperative radiographic outcome for 27 patients with intracapsular fracture of the femoral neck

Fracture types	Preoperative data				Postoperative data										
	Age, Gender		Side		Implant type				Reduction grade			Screw placement		Femoral N-S angle	
	<50 y	>50 y													
	M	F	M	F	Rt.	Lt.	CS	DHS/DRS	I	II	III	Proper	Improper	$>130^\circ$	$<130^\circ$
Garden I	2	0	1	4	3	4	3	4	7	0	0	5	2	7	0
Garden II	6	3	3	5	6	11	15	2	17	0	0	15	2	16	1
Garden III	1	1	1	0	1	2	2	1	3	0	0	2	1	3	0
Total	9	4	5	9	10	17	20	7	27	0	0	22	5	26	1

Rt.: Right Lt.: Left CS: Cannulated Screws DHS/DRS: DHS/DRS composite

N-S angle: Neck-Shaft angle, M: Male, F: Female



**Figure 1-D and Figure 1-E.** Antero-Posterior and lateral radiographs were made two months postoperative show the fracture has lost reduction and the screws migrated superiorly within the head. In the lateral view Figure 1-E the screws of the DHS/DRS composite lost its parallelism



**Figure 1-F.** The fracture healed in varus neck-shaft angle and the DHS/DRS composite was removed. No evidence of osteonecrosis can be seen

### Functional outcome

Equality of the lower limbs achieved for 25 patients (92.60%), shortening 1.5 and 1 cm of the injured limb was reported in two patients (7.40%). Full mobility of the hip compared to the contralateral side was reported in 26 patients (96.30%) and limited hip mobility in all directions was reported in one patient (3.70%) According to the Harris hip score<sup>13</sup> 25 patients (92.60%) obtained full score (100 point), two patients (7.40%) (Cases 5 and 22) obtained 66 and 91 points respectively (Table 2). The overall hip score averaged 98.40 point (range: 66-100)

### Complications

None of the patients developed infections, deep venous thrombosis or clinical manifestation of pulmonary embolism.

Lost reduction with lost parallelism between screws of the DHS/DRS composite and varus neck-shaft angle was reported by two months postoperative in one case (3.70%) (Figure 1-D through 1-F).

Reoperation during the first postoperative year was performed in two patients (7.40%), in one (case 5) for removal of the three cancellous screws (Figure 2-B through 2-D) and in the (case 22) for removal of the DRS, which had protruded laterally annoying the patient (Figure 1-D through 1-F).

Avascular necrosis was seen by one and half year postoperative in one patient (3.70%) (Table 2). This is a female patient aged 17 years at the time of

the surgery, she was transferred from other hospital while the injured limb in the skin traction. The fracture was fixed by third day post-injury and healing observed by third month postoperative. She got pregnancy by end of the second year postoperative; therefore, the radiological follow-up was ceased. By end of the third year postoperative, osteoarthritis of the hip developed (Figure 2-A through 2-E)

**Table 2.** Clinical outcome for 27 patients were managed for intracapsular fracture of the femoral neck

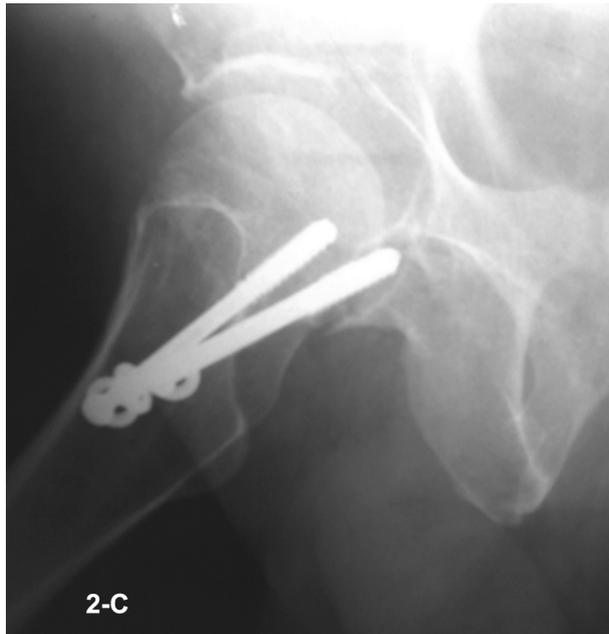
Fracture type	Bone healing		Hip motion		Limb equality		Osteo-necrosis	Hip score	
	Unite	nonunion	Equal	Limited	Equal	Short		=100	<100
Garden I	7	0	7	0	7	0	0	7	0
Garden II	17	0	17	0	16	1	0	16	1
Garden III	3	0	2	1	2	1	1	2	1
Total	27	0	26	1	25	2	1	25	2



**Figure 2-A.** Preoperative A-P radiograph for hip joint of seventeen-years-old girl with a Garden grade III fracture of the left femur



**Figure 2 B**



**Figure 2 C**

**Figure 2-B and 2-C.** Antero-posterior and lateral views radiograph was made four months postoperative. The screws placement is deemed improper. However, The fracture healed in an anatomic position



**Figure 2-D.** Complete aseptic necrosis of the femoral head and osteoarthritis of the hip are seen three years postoperative. Sclerotic changes are evident in the walls of the cancellous screws channels

## DISCUSSION

It has been agreed that the intracapsular femoral neck fractures are associated with hemarthrosis and the fluid in the intact capsule elevates the intracapsular pressure to a level could tamponades the vascular supply of the femoral head. Nevertheless, the capsular incision in order to reduce the intracapsular pressure remains a point of controversy. Creation of a novel portal for capsular decompression that does not threaten the capsular-related blood vessels therefore, seems an attractive option.

The studies that concerned with capsular decompression can be grouped into two groups. First group decompressed the capsule by aspiration, reported relative improvement of the femoral head circulation<sup>1-5</sup>. Other group has used capsular incision for the decompression, reported negative impact<sup>6,7,11</sup>. The novel technique differs from the previous techniques in terms of safety and efficiency. While the capsular incision has been considered one possible cause for failure of improvement of femoral head circulation because it may damage the anterior blood vessels<sup>2,3,6,7</sup>. The present portal keeps integrity of the capsule as well as the related blood vessels. Similarly, the needle aspiration of the capsule has not threatened the blood vessels, however it seems a transient portal and its long-term effect has not been proven. Theoretically, the trans-osseous portal persists longer, this provides sufficient period for drainage of probable attacks of bleeding that follow the fracture reduction and introduction of the implants. Therefore, the normally equal intra and extra capsular pressure, <sup>4</sup>likely will be balanced.

High rates of osteonecrosis of the femoral head after the intracapsular femoral neck fractures have been reported<sup>7,11</sup>. Upadhyay et al. reported 16.3% of avascular necrosis equally distributed between two groups of patients. The first group was treated with open reduction through T-shaped capsular incision and the second group was treated by closed reduction without capsular decompression<sup>7</sup>. It is clear that the blood supply of the femoral head had exposed to stress in both group either through opening of the capsule or through tamponade effect of the haematoma when the capsular decompression is omitted.

Position of the limb prior to the surgery plays an important role in development of the osteonecrosis. The capsule becomes tight in extension and in me-

dial rotation<sup>2,4</sup>. Strömquist et al reported pressures of 280 and 360 mm Hg in two cases examine with leg in extension and medial rotation<sup>3</sup>. Soto-Hall et al. however reported that the capacity of the joint was greatest in flexion and lateral rotation of a hip<sup>2</sup>.

The length of time the human femoral head can survive without a blood supply is unknown<sup>4</sup>. However, Henard and Calandruccio produced avascular necrosis of the capital femoral epiphysis of immature dogs after holding the hip in abduction, extension and medial rotation for six hours<sup>14</sup>. Woodhouse, using adult dogs, found that avascular necrosis developed when intracapsular pressure was maintained at 50 mmHg for 12 hours after osteotomy of the femoral neck<sup>15</sup>. Therefore, several authors have suggested that patient should not be placed in traction but nursed with the hip in semi flexion and lateral rotation<sup>2,3</sup>. Harri et al. observed osteonecrosis in one third of a group of patients with femoral neck fracture have been nursed prior to the surgery in the tibial traction for a period ranged from 2-7 days<sup>11</sup>. In present study, the patient that developed osteonecrosis was transferred from other hospital with the injured limb in skin traction.

The timing of surgery for femoral neck fractures remains a point of debate. The available data is indecisive on whether this fracture should be operated emergently, or can be delayed. Upadhyay et al. reported that internal fixation was equally effective within one week of injury and the timing of surgery did not influence the rate of union or the development of osteonecrosis<sup>7</sup>. In the present study, the time lags before sugary averaged 3.7 days. All fractures united within an average period of 11.8 weeks. Therefore, we think that the timing of surgery can be either early or delayed as deemed appropriate by the surgeon. This entails that the internal fixation of the femoral neck fractures should be performed as soon as the patient is considered stable.

Age of the patient play a role in the development of the osteonecrosis. As was mentioned, osteonecrosis developed in the young doges after shorter period of increased intracapsular pressure compared to the adult dogs<sup>14,15</sup>. Prolzman and Burkhalter suggested that the patients who have normal bone stock have a higher risk of avascular necrosis<sup>16</sup>. In the present study, a patient aged 17 years developed osteonecrosis.

## Conclusions

Results of the present study supported that the transosseous capsular decompression had evacuated the intracapsular haematoma and had not threatened the capsular integrity. Preoperative traction of the injured limb, particularly in the young patient, played a role in development of osteonecrosis of the femoral head.

**Conflict of interest:** The authors declare that they have no conflict of interest

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