



November 5, 2003

To Fellows and Members of HKCOS and HKOA

Dear Colleagues,

Though the SARS epidemic had died down for some months, Hong Kong is again drowned with the witch-hunting and fault-finding exercise after the recent release of the two reports on this demoralising infectious disease. The orthopaedic professionals were not too much affected during the acute period where many of us already prepared for the possible complications of the high dose steroid treatment. The recent sensational media coverage of this complication had prompted the two orthopaedic professional organisations, the Hong Kong College of Orthopaedic Surgeons and the Hong Kong Orthopaedic Association, to issue a statement to our fellows on this clinical problem. The councils of the two organisations directed the Joint Replacement Interest group, led by Dr. Peter KY Chiu and Dr. KH Chiu, to draft a Fact Sheet basing on the thorough and objective literature review and clinical experience from our senior fellows. Realising many of the problems concerning Avascular Necrosis (AVN) of bone remain unsolved with our current scientific knowledge; the Fact Sheet is drafted with the consensus to serve as clinical guidelines for our understanding and careful clinical judgment when managing these very unfortunate patients.

The Fact Sheet is fully endorsed by the Councils of the Hong Kong College of Orthopaedic Surgeons and the Hong Kong Orthopaedic Association.

Yours truly

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The Hong Kong College of Orthopaedic Surgeons

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# **Fact Sheet On Avascular Necrosis**

## **In Patients Recovered From SARS**

This Fact Sheet, endorsed by the councils of The Hong Kong College of Orthopaedic Surgeons and The Hong Kong Orthopaedic Association, serves to facilitate orthopaedic surgeons in communicating with their patients who suffer from avascular necrosis.

Its intention is not to recommend any particular surgical intervention, and it should not replace the judgment and decision of the orthopaedic surgeons.

While due care has been taken to prepare the materials included in this Fact Sheet, the accuracy of the original publications could not be warranted. The Hong Kong College of Orthopaedic Surgeons and The Hong Kong Orthopaedic Association claim not to be responsible for any misrepresentation concerning safety and efficacy that might exist in the original publications.

1. **What is avascular necrosis (AVN)?** AVN is believed to follow impairment of circulation to the bones. A number of joints may be affected, but it occurs most commonly in the hip joint. The exact cause of AVN cannot always be identified. However, several conditions are considered as risk factors, for example trauma causing injury to the supplying blood vessel, alcohol abuse, connective tissue diseases and steroid treatment. The condition may remain asymptomatic, or progress with bone deformation and pain. The chance for AVN to occur is not predictable. It is also unknown whether the virus that causes SARS may lead to this problem.
2. **What is the chance of developing AVN after steroid treatment?** The reported prevalence of AVN of the femoral head in patients who had received steroid ranged from 0% to 52% (Felson and Anderson 1987). However, the steroid doses and duration used in the reported series were rather heterogenous. Most patients had underlying diseases e.g. vasculitis which themselves could affect the blood circulation in bony tissue, hence the effect of steroid causing AVN was not that certain among these patients. In other words, the true prevalence, the dose of corticosteroids necessary to induce AVN, and the natural history of steroid-induced AVN remain ill defined. There is very little information about AVN of the medial femoral condyles in the knee, and that of the talus and the humeral head with regard to its relationship with steroid administration. It is possible that such conditions were under-estimated since they may be asymptomatic, and many patients present late and late AVN cannot be distinguished from other conditions such as osteoarthritis.
3. **If the patient has no pain, what is the chance that there will be AVN?** Not all early AVN will present with pain, and early AVN may not be detected by ordinary radiographs. Special imaging methods, such as magnetic resonance imaging (MRI) will be helpful in detecting early AVN. MRI has 99% sensitivity and specificity for diagnosing AVN. If there is no joint pain, the chance that one will have AVN after steroid treatment should be small. The current local data suggests that it may be as low as 3 - 4%. For some patients, the MRI findings may be inconclusive, and repeated MRI scans may be needed.
4. **If the patient has pain, what is the chance that there will be AVN?** If one experiences joint pain after steroid treatment, it does not mean that AVN must be present. MRI will be helpful in detecting early AVN. Special imaging methods, such as magnetic resonance imaging (MRI) will be helpful in detecting early AVN. MRI has 99% sensitivity and specificity for diagnosing AVN. The current local data suggests that the chance may be 40% or higher.

5. **How many stages of AVN are there for the hip? What can be done for each stage?** There are several classification systems and each has different number of stages. The one that will be used for the hip joint is proposed by University of Pennsylvania (Steinberg et al. 1995), and it is from stages 0 to 6. The stage 0 depicts there is no radiological evidence of AVN. Stages I to II are the earlier stages when the joint does not show any collapse. The radiograph is normal in stage I, and the AVN can be seen in the radiograph in stage II. Core decompression or vascularized bone grafting may be used to relieve symptoms and to prevent the joint from future collapse. Stages III to IV are intermediate stages when the joint starts to collapse, vascularized bone grafting may be helpful. For advanced stages (stages V and VI), joint replacement may be needed. (See pages 11 -12 for details)
6. **How many stages of AVN are there for the knee? What can be done for each stage?** There are several classification systems and each has different number of stages. The staging system that will be used is the one proposed by Mont et al. (1997), and it is from stages I to IV. Stages I to II are the earlier stages. The radiograph is normal in stage I, and the AVN can be seen in the radiograph in stage II. Core decompression with or without bone grafting may be used to relieve symptoms and to prevent the joint from future collapse. In some cases, arthroscopic debridement may help. Stages III to IV are the advanced stages when the joint shows collapse, joint replacement may be needed. (See page 12 for details)
7. **If the patient has early AVN, what is the chance of progression to late stage with collapse of the joint surface?** The exact chance is unclear. Not all AVN will progress; the reported chance ranged from 50% to 85% without surgical intervention. For symptomatic AVN, about 70% to 80% progressed or showed collapse if left untreated (Mont and Hungerford 1995). For asymptomatic AVN, there is very little information, but the chance was reported to be much lower in one study (Jergesen and Khan 1997). Various factors affect whether early AVN will progress to collapse of the joint surface. These include the stages, the extent, and the location of the AVN. If AVN affects only a small part over the non-weight-bearing part of the femoral head, the prognosis is good; it has been reported that less than 20% will progress to collapse (Ohzono et al. 1991). However, if a large part of the femoral head is affected over the weight-bearing part, then there is a very high chance of collapse; it has been reported that more than 70% will progress to collapse (Shimizu et al. 1994).
8. **Does the amount of pain correlate with the degree of severity of AVN?** Usually the amount of pain correlates with the degree of severity, especially in early AVN and when a significant part of the joint is affected. On the other hand, the pain may be mild and transient, and some patients with AVN do not have much pain.

9. **What will happen if the MRI shows that the patient has AVN?** That depends on the extent of the joint involvement and the pain. The patient will see the orthopaedic surgeon who will assess the conditions carefully. Many patients who have AVN do not need any operation, the condition will be closely observed. However, for the patients who experience significant pain and the MRI shows that AVN affects large portion of the affected joint, they will have a higher chance of future joint collapse. In this case they may benefit from surgical intervention. The orthopaedic surgeon will discuss with the patient in details.
10. **Is there any conservative treatment that has been proven to be effective?** There is no study to show that bed rest it self has any effect on the outcome of AVN. There is no known drug that has been proven to be effective in treating steroid-induced AVN. The patient will be given pain killers to control the joint pain. Potent bisphosphonates have been used locally, but its efficacy in preventing further joint collapse has yet to be proven. Non-pharmaceutical measures such as hyperbaric oxygen therapy (Reis et al.2003) and shock wave treatment have been used, but there is very little information about their effectiveness especially when the AVN is due to steroid therapy.
11. **What are the surgical treatment options for AVN?** For early AVN, the orthopaedic surgeon may offer several surgical intervention options. These include core decompression and vascularised bone grafting. The pros and cons of each option will be explained. Of course the patient may choose to have close monitoring of their conditions, since early AVN may not necessarily progress.
12. **What is core decompression?** Core decompression involves removing a core of unhealthy bone from the region affected by AVN. This operation may improve the blood supply to the femoral head. This procedure has a good chance in improving the joint pain, and may prevent future collapse of the bone. The procedure will be performed under general anaesthesia or epidural / spinal anaesthesia. The operation will last for one hour if there is involvement of one site; it will take longer if there is multiple sites involvement. The incision is about 2 – 3 centimetres long. The patient will need to stay in the hospital for a few days or a week. The overall complication rate is low; there is a less than 1% chance to have a fracture at the operative site. It is important for the patient to use a pair of crutches for 6 weeks after the operation. It is also important to avoid fall in the postoperative period. Many papers have been published, but there is still controversy on its effectiveness. There is lack of high level evidence to support core decompression as an effective treatment for early AVN. Two randomized controlled trials produced conflicting results (Stulberg et al. 1991; Koo et al. 1995). In several systematic review articles, the success rates for stages I to III ranged from 15-48% with conservative treatment and 22-71% with core decompression. The success rates of core decompression have been reported to be around 60-80% for early stages; it drops to less than 20% in late stages (Castro and Barrack 2000).

13. **What is vascularized iliac crest grafting?** The procedure will be performed under general anaesthesia. The surgical wound is about 20 centimetres in length, over the groin and thigh region. The unhealthy bone will be removed from the affected area, and then the orthopaedic surgeon will put a living piece of bone back. The piece of bone will be taken from the pelvis, and the blood vessels that supply the bone graft will be preserved. The patient will need about 1 to 2 weeks of rest on the bed, 8 weeks of non-weight-bearing walking, followed by 4 weeks of protected-weight-bearing. Such procedures may improve the joint pain, and may prevent future collapse in some patients (Leung 1996). For stage II AVN of the hip, the success rate is about 75%; it is about 50% for stage III AVN. The procedure may be complicated by wound problems including incision site gapping, and occasional lateral cutaneous nerve injury, but the chance is below 5%.
14. **What is vascularized fibular grafting?** The procedure will be performed under general anaesthesia. The orthopaedic surgeon will remove part of the unhealthy bone from the affected area, and then put a living piece of bone taken from the leg. This procedure aims to improve the blood supply to the femoral head. In addition, that living piece of bone will provide living bone cell and additional mechanical support for the weakened femoral head bone. The ultimate aim is to prevent future deformation of the bone which will lead to early degeneration of the joint. The procedure takes 6 to 8 hours. It requires two teams of surgeons operating simultaneously. One team will remove the unhealthy bone from the femoral head while the other team will take the living piece of bone together with blood vessels from the leg at the same time. That piece of bone will then be transferred to the femoral head and its blood vessels will be reconnected to the surrounding blood vessels of the hip. The patient may stay in the hospital for one to two week. The physiotherapists will instruct the patient to undergo a rehabilitation program including mobilization and muscle strengthening exercise. The patient has to walk with crutches for at least 12 weeks. The overall complication rate is low. Potential complications include wound infection (< 1%), fracture of the operated hip (< 2%) and donor site problems such as scar adhesion or contracture of nearby tendons (< 1%) and partial nerve injury (< 10%). For stage II AVN of the hip, it has been reported that 80 to 90% will not need hip replacement within the next 5 years (Urbaniak et al. 1995; Plakseychuk et al 2003).

15. **If the patient suffers from AVN, how can he / she choose between core decompression and vascularized bone graft?** The literature support is inconclusive. It is generally accepted that core decompression is recommended for early stage of the disease. Some surgeons prefer vascularized bone graft if the extent of involvement is large, even for early stages. In one study, the results of vascularized fibular graft were compared to that of core decompression. For stage I hips, both methods were equally good. For stage II hips, about 10% of hips treated with vascularized fibular graft compared with over 30% of hips treated with core decompression were converted to THR after follow-up for more than 4 years (Scully et al. 1998). However, vascularized bone grafting procedures are more major and complicated. They may carry higher complication rates and may need longer period of recovery.
16. **If the patient has AVN, what is the chance of requiring hip replacement eventually?** The exact chance is unknown. Not all early AVN will progress to late stages. Not all AVN patients with collapse and secondary OA changes will need THR.
17. **What is hip replacement?** The procedure will be performed under general anaesthesia or epidural / spinal anaesthesia. The damaged part of the hip joint will be removed and replaced with synthetic materials including metal, special plastics, and sometimes ceramics or bone cement. The procedure usually takes 2 hours. A number of complications may occur; the commonest ones are wound infection (about 1%) and dislocation (about 2%). In the long run, the hip replacement may fail due to loosening or wear – about 10 – 20% of patients will need revision surgery after 10 to 15 years.

## References:

- This is NOT a comprehensive literature review.
  - It is hoped that the fellow orthopaedic surgeons who want to understand the situation in greater details will find the annotated references useful.
1. **Felson DT, Anderson JJ. A cross-study evaluation of the association between steroid dose and bolus steroids and avascular necrosis of the bone. *Lancet* 1987; 1:902-906.**
    - MEDLINE searches, 157 papers were identified, a review of 22 papers with sufficient information
    - Diagnosis include symptoms alone or X-ray changes
    - There was strong correlation between daily total dose and AVN risk
    - 4-6% increase in risk for every 10mg/day rise in daily steroid dose
    - Bolus dose did not correlate with AVN risk
  2. **Steinberg ME, Hayken GD, Steinberg DR. A quantitative system for staging avascular necrosis. *J Bone Joint Surg Br* 1995; 77-B:34-41.**
    - Please refer to pages 11-12.
  3. **Mont MA, Hungerford DS. Osteonecrosis of the shoulder, knee, and ankle. In Urbaniak JR, Jones JP, eds: *Osteonecrosis: Etiology, Diagnosis, and Treatment*. Rosemont, IL, American Academy of Orthopaedic Surgeons, P. 429, 1997.**
    - Please refer to Page 12
  4. **Mont MA, Hungerford DS. Current concepts review: Non-traumatic avascular necrosis of the femoral head. *J Bone Joint Surg (Am)* 77-A:459-474, 1995.**
    - 21 studies on 819 hips with symptomatic AVN treated non-operatively were reviewed
    - There was no progression of AVN and no femoral collapse in 26% of hips after an average follow-up of less than 3 years.
    - 35% stage I hips, 31 stage II hips and 13 stage III hips did not need any surgical intervention.
  5. **Jergesen HE, Kahn AS. The natural history of untreated asymptomatic hips in patients who have non-traumatic avascular necrosis. *J Bone Joint Surg (Am)* 79-A:359-63, 1997.**
    - Non-traumatic AVN and pain in one hip, the other hip was asymptomatic; routine CT scan or MRI was not done in the other hip
    - For the 19 patients had abnormal radiograph of the other hip, 14 became painful after a minimum follow-up of 5 years
    - For the 23 patients had normal radiograph of the other hip; 4 became painful after a minimum follow-up of 5 years
  6. **Shimizu K, Moriya H, Akita T, Sakamoto M, Suguro T. Prediction of collapse with magnetic resonance imaging of avascular necrosis of the femoral head. *J Bone Joint Surg (Am)* 76-A:215-223, 1994.**
    - 66 hips with early AVN in 55 patients were followed up
    - 32% collapsed after an average follow-up of 32 months
    - In 23 hips, the AVN area was more than 2/3 of the weight bearing area; 74% showed collapse of the femoral head

7. **Ohzono K, Saito M, Takaoka K, Ono K, Saito S, Nishina T, Kadowaki T. Natural history of nontraumatic avascular necrosis of the femoral head. J Bone Joint Surg (Br) 73-B:68-72, 1991.**
  - 115 AVN hips in 87 patients were followed up for over 5 years; it was induced by steroid in 69 hips
  - MRI showed a demarcation line in 89 hips; 94% of the femoral head collapsed if the AVN affected the weight bearing of the femoral head; it was 13% if the AVN did not extend to the weight bearing part.
  - MRI showed a cystic lesion in 22 hips; 100% collapsed if the cystic lesion occurred in the subchondral region over the weight bearing of the femoral head; it was 13% if the cystic lesion was away from the subchondral region.
  
8. **Reis ND, Schwartz O, Militianu D, Ramon Y, Levin D, Norman D, Melamed Y, Shupak A, Goldsher D, Zinman C. Hyperbaric oxygen therapy as a treatment for stage-I avascular necrosis of the femoral head. J Bone Joint Surgery (Br) 85-B:371-5, 2003.**
  - 12 patients (16 hips) suffered from stage I AVN of the femoral head; daily hyperbaric oxygen therapy was given for 100 days to each patient, each session involved breathing 100% oxygen at 2 to 2.4 atmospheres absolute in a pressure chamber for 90 minutes and using a mask breathing system.
  - 10 patients (13 hips) had idiopathic AVN; the MRI returned to normal in all.
  - 2 patients (3 hips) has steroid-induced AVN, one for SLE (bilateral) and one for CRF (unilateral); both hips in the SLE patient progressed to stage II and were symptomatic, the hip in the CRF patient progressed to stage III and required THR.
  
9. **Stulberg BN, Davis AW, Bauer TW, Levine M, Easley K. Osteonecrosis of the femoral head. A prospective randomized treatment protocol Clin Orthop 268:140-151, 1991.**
  - 55 AVN hips (36 patients), randomized to core decompression (29 hips) and conservative treatment (26 hips) with non-weight bearing walking for at least 6 weeks until symptoms subside
  - For stage I (15 hips), 5 of the 10 core-decompressed and 4 of the 5 conservatively treated hips showed radiological progression, 3 of the 10 core-decompressed and 4 of the 5 conservatively treated hips needed further hip operations.
  - For stage II (14 hips), 2 of the 7 core-decompressed and 3 of the 7 conservatively treated hips showed radiological progression, 2 of the 7 core-decompressed and all of the 7 conservatively treated hips needed further hip operations.
  - For stage III (21 hips), 0 of the 11 core-decompressed & 7 of the 10 conservatively treated hips showed radiological progression, 3 of the 11 core-decompressed & 9 of the 10 conservatively treated hips needed further hip operations.
  - For all 3 stages, 25% of core-decompressed and 50% of the conservatively treated hips showed radiological progression, 29% of the core-decompressed and 91% of the conservatively treated hips needed further hip operations.
  
10. **Koo KH, Kim R, Ko GH, Song HR, Jeong ST, Cho SH. Preventing collapse in early osteonecrosis of the femoral head. A randomized clinical trial of core decompression J Bone Joint Surg (Br) 77-B:870-874, 1995.**
  - 37 early (stages I – III) AVN hips randomized into core decompression group (18 hips) and conservative treatment group (19 hips)
  - In the core-decompressed group, 10 of the 18 hips were painful but the pain was relieved in 9; in the non-operated group, 4 of the 19 hips were painful but the pain persisted in 3.
  - 78% of core-decompressed hips and 79% of the non-operated hips developed collapse after a minimum follow-up of 2 years.

11. **Castro FP, Barrack RL. Core decompression and conservative treatment for avascular necrosis of the femoral head: a Meta-analysis. *Am J of Orthopedics* 29(3):187-194, 2000.**
- 1966-1998 Medline English papers reviewed 22 studies with single core decompression and 8 studies with conservative treatment included.
  - Success rates for core decompression in Steinberg stages I, II and III were 84%, 63%, and 29% respectively.
  - Success rates for conservative group in stages I, II and III were 61%, 59% and 25 % respectively.
  - Chi-square analysis showed the success rate of core decompression to be significantly higher for stage I hips only.
12. **Urbaniak JR, Coogan PG, Gunneson EB, Nunley JA. Treatment of osteonecrosis of the femoral head with free vascularized fibular grafting. A long-term follow-up study of one hundred and three hips. *J Bone Joint Surg (Am)* 77-A:681-694, 1995.**
- 103 symptomatic AVN hips in 89 patients under the age of 50 years were followed up for over 5 years; it was induced by steroid in 17% of hips
  - 19 hips were in stage II; Harris hip score improved from 56 to 80; 11% were converted to THR
  - 22 hips were in stage III; Harris hip score improved from 52 to 85; 23% were converted to THR
  - 62 hips were post-collapse to start with; 28% were converted to THR
  - About 10% reported discomfort in the ankle with activity
  - There were 2 stress fractures at the site of the core.
13. **Plakseychuk AY, Kim SY, Park BC, Varitimidis SE, Rubash HE, Sotereanos DG. Vascularized compared with nonvascular fibular grafting for the treatment of osteonecrosis of the femoral head. *J Bone Joint Surg (Am)* 85-A:589-596, 2003.**
- 220 hips were treated with free vascularized fibular grafting in Pittsburg, USA, and 123 hips were treated with non-vascularized fibular grafting in Taegu, Korea.
  - case-controlled study, 50 hips from each site matched by stage of AVN, size of lesion, aetiology and pre-operative Harris hip score, and followed up for at least 3 years.
  - There were 14 pairs of stage I hips; no vascularized hips showed collapse, but 42% of the non-vascularized hips showed collapse.
  - There were 21 pairs of stage II hips; 14% of the vascularized hips and 66% of the non-vascularized hips showed collapse.
14. **Leung PC. Femoral head reconstruction and revascularization. Treatment for ischemic necrosis. *Clin Orthop* 323:139-145, 1996.**
- 21 AVN hips in 18 patients were followed up for 4 to 12 years; it was induced by steroid in 7 hips
  - 6 hips were in stage III; good results
  - 15 hips were post-collapse to start with; good pain control but collapse was common
  - there was an average loss of 25 degrees of flexion and 20 degrees of abduction

**15. Scully SP, Aaron RK, Urbaniak JR. Survival analysis of hips treated with core decompression or vascularized fibular grafting because of avascular necrosis. J Bone Joint Surg (Am) 80-A:1270-1275, 1998.**

- 614 hips were treated with free vascularized fibular grafting in Durham, USA, and 98 hips were treated with core decompression in Providence, USA.
- Cases were stratified according to age and stage of AVN.
- Survival analysis was performed with conversion to THR as the end point; the follow-up was 50 months.
- There were 11 stage I hips; all of the 3 vascularized hips or the 8 core decompression hips survived.
- There were 126 stage II hips; 89% of the 111 vascularized hips and 65% of the 15 core decompression hips survived.
- There were 547 hips that were post-collapse; 81% of the 500 vascularized hips and 21% of the 47 core decompression hips survived.

## Summary of the staging systems & the management protocols

1. AVN of the femoral head is staged by the University of Pennsylvania System.

| Stage            | Criteria  |
|------------------|---|
| <b>Stage 0 *</b> | <b>Normal MRI</b>   |
| <b>Stage I</b>   | <b>Abnormal MRI, normal radiograph</b>  |
| <b>A</b>         | Mild (<15% of head involvement)   |
| <b>B</b>         | Moderate (15 to 30% head involvement)   |
| <b>C</b>         | Severe (>30% head involvement)  |
| <b>Stage II</b>  | <b>Abnormal radiograph showing cystic and sclerotic changes in the femoral head</b> |
| <b>A</b>         | Mild (<15% of head involvement)   |
| <b>B</b>         | Moderate (15 to 30% head involvement)   |
| <b>C</b>         | Severe (>30% head involvement)  |
| <b>Stage III</b> | <b>Subchondral collapse producing a crescent sign</b>                               |
| <b>A</b>         | Mild (<15% of articular surface involvement)  |
| <b>B</b>         | Moderate (15 to 30% articular surface involvement)                                  |
| <b>C</b>         | Severe (>30% articular involvement)   |
| <b>Stage IV</b>  | <b>Flattening of the femoral head</b>   |
| <b>A</b>         | Mild (<15% of articular surface and <2 mm depression)                               |
| <b>B</b>         | Moderate (15 to 30% of articular surface or 2 to 4 mm depression)                   |
| <b>C</b>         | Severe (>30% articular surface or >4 mm depression)                                 |
| <b>Stage V</b>   | <b>Joint narrowing with or without acetabular involvement</b>                       |
| <b>A</b>         | Mild  |
| <b>B</b>         | Moderate  |
| <b>C</b>         | Severe  |
| <b>Stage VI</b>  | <b>Advanced degenerative changes</b>  |

\* Stage 0 is modified for the MRI screening program in HA Hospitals, X-ray will not be taken or used as a criterion, and the assessment will be based on MRI alone.

|                |  |
|----------------|--|
| Stage 0 – I †  | Observe  |
| Stage I † - II | Observe or Core decompression                            |
| Stage II       | Observe or Core decompression or Vascularised bone graft |
| Stage III – IV | Observe or Vascularised bone graft                       |
| Stage IV – VI  | Observe or Hip joint replacement                         |

† In HA hospitals, it has been agreed that one will observe if it is an asymptomatic stage IA AVN; the patient will be offered observation or core decompression if it is an asymptomatic stage 1 B or C AVN.

2. Avascular necrosis of the knee is staged as described by Mont et al.

| Stage      | Criteria   |
|------------|--|
| <b>I</b>   | <b>Normal radiograph but abnormal MRI</b>                        |
| <b>II</b>  | <b>Sclerotic or cystic changes, or both, on plain radiograph</b> |
| <b>III</b> | <b>Subchondral collapse (crescent sign)</b>                      |
| <b>IV</b>  | <b>Degenerative changes on the opposite of the joint</b>         |

|           |  |
|-----------|--|
| Stage I   | Observe                                    |
| Stage II  | Observe or Core decompression or Osteotomy |
| Stage III | Observe or Osteotomy                       |
| Stage IV  | Observe or Knee joint replacement          |

**-End-**