Iranian Journal of Orthopaedic Surgery
Vol 9, No 1 (Serial No 34), Winter 2011:38-43

مجله جراحی استخوان و مفاصل ایران
دوره نهم، شماره ۱ (شماره مسلسل ۳٤)، زمستان ۱۳۸۹، صفحه‌های ٤۳-۳۸

Femoroacetabular Impingement: A Newly Opened Window

*Javad Parvizi, MD, FRCS; **S Mehdi Jafari, MD

The pathomechanisms of secondary osteoarthritis (OA) of the hip such as avascular necrosis (AVN), posttraumatic OA, infection, and hip dysplasia were widely known. However, until the introduction of the theory of femoroacetabular impingement (FAI) syndrome by Ganz et al [(1)] the exact pathogenesis for early onset idiopathic OA in hips without dysplasia was covered. They described the clinical, radiographic and intraoperative findings of this syndrome. From the advent of this topic a surge in the number of the published articles regarding the various aspects of FAI has appeared. This cleanly reveals its clinical importance. Today most physicians believe that untreated impingement or nonsurgical treatment leads to early OA, whereas the optimal surgical treatment would basically hamper or postpone the need for hip replacement.
FAI initiates from abutment of the femoral head-neck junction with acetabular-labral complex due to the morphologic deformities of femoral head or acetabulum. Any developmental, posttraumatic or surgically induced deformity can alter the normal anatomic shape of the femoroacetabular unit and then this deformity elicits the impingement in the terminal range of hip motion. New evidences show that in young active patients, subtle morphologic deviations affecting the proximal femur and/or the acetabulum are the most common causes of FAI [(1)].

Pathoanatomy

Two general categories of FAI have been documented: pincer and cam types. Cam type is more frequent in young male athletes while pincer type is more common in middle-aged and older women. Occurrence of these types in isolation is rare, and the combination of both known as mixed type is more prevalent. In reality, some if not many of the patients have components of both types, although usually one component is predominant.

1. Cam type

Cam impingement is the result of decreased head-neck offset or ratio. The anterosuperior head neck junction, which is normally concave, has become either convex or flattened. This abnormal morphology may involve the femoral head also which then becomes aspherical. With flexion and internal rotation of the hip the abnormal osseous hump rotates into the joint producing a cam effect. Then this hump impacts the acetabular rim so that the articular cartilage starts to experience shearing stress and continues to delaminate like "carpet peeling off the floor". Usually the cartilage at anterosuperior and lateral acetabular sides is affected first. This type of chondral damage, which can lead to large cartilage abrasions, flaps or detachment leads to damage of the adjacent labrum in the form of a labral tear and/or detachment. Subsequently repetitive osseous impingement results in osteophyte formation on the anterior femoral neck which further worsens the problem. It can occur in abnormal physeal development, subclinical slipped upper femoral epiphysis (SUFE), adult osteonecrosis, elliptical femoral head, Legg-Calve-Perthes disease, and malunited femoral neck fractures [(3)].

2. Pincer type

The over-coverage of the femoral head by the anterior rim of the acetabulum can be caused by acetabular retroversion, protrusio acetabuli, overcorrection in periacetabular osteotomy, coxa profunda, coxa vara and so forth. This over-coverage produces a linear contact between the acetabular rim and the femoral neck. In pure pincer type impingement the predominant abnormality involves the morphology of the acetabulum with no abnormality in sphericity of the femoral head. The damage characteristically initiates with degeneration of the labrum and formation of an intralabral ganglion plus ossification of the overhanging rim. This ossification results in abnormal deepening of the acetabulum and worsens the overcoverage. The repetitive contact occurs more often anteriorly and this often results in a contrecoup chondral injury along the posteroinferior acetabulum [(1)]. In this type of FAI acetabular cartilage lesions are often confined to a small region along the acetabular rim and tend to be more benign than the lesions usually seen in cam type.

Clinical Manifestation

The diagnosis of FAI is based on the clinical history and physical examination and then is supported by imaging findings.

History

Clinically, FAI manifests as gradual onset of unilateral and rarely bilateral [(10)] groin pain in an active young or middle-aged patient with decreased range of motion in flexion, adduction, and internal rotation. In over 80% of the cases the location of pain is in the groin [(19)]. Initially the pain is intermittent and starts after a minor trauma. Gradually the pain exacerbates by excessive demand on hip and prolonged walking or sitting with hip extremely flexed. When the patient complains of knee pain, it is always critical that the

Received: 3 months before printing ; Accepted: 1 month before printing

*Orthopaedic Surgoen, Department of Orthopaedic Surgery, Rothman Institute at Thomas Jefferson University Hospital, Philadelphia, Pennsylvania.
**Orthopaedic Surgoen, Department of Orthopaedic Surgery, Tehran University of Medical Sciences, Tehran, Iran.

surgeons assess the ipsilateral hip joint as a possible source of pain. Occasionally the patient may report locking, catching, snapping and giving-way symptoms which can indicate a labral tear or delamination injury of the articular cartilage. Seventy percent of patients report night pain[11]. Patients typically complain of decreased ability to perform activities of daily living and sports activities. Athletes with FAI may report difficulty with squatting, lateral/cutting movements, and starting/stopping [31].
Between the onset of symptoms and the diagnosis of the FAI, a mean delay of 21 months to 5.4 years, with an average of 3.3 previous doctor visits has been reported [11,12,19]. Sometimes these patients have even had laparoscopy, laparotomy, knee arthroscopy, spine surgery, inguinal hernia repair, Iliotibial band or trochanteric bursitis procedure, and psoas or musculotendinous release as the result of a missed diagnosis [1, 11].

Physical Examination
The most important physical finding is the anterior impingement test which is positive in 95-99% of these cases [1, 11, 19]. This test correlates with the acetabular labral or rim chondral lesions [4]. The test shows limitation of internal rotation and adduction in passive flexion of the hip to 90º, and this position produces a sharp pain.
Pain induced by extension and external rotation of the patient's leg in prone position indicates posteroinferior impingement of the femoral head-neck junction against the posteroinferior aspect of the acetabular rim [1, 17].
Limping and provocative maneuvers such as classic Trendelenberg test, Thomas test, anterior apprehension test, and the bicycle test are suggestive but not specific [11, 18]. Abnormality of the FABER (flexion, abduction, and external rotation) test or Patrick test can be found in 97% of patients but the validity of these findings has to be evaluated [19].

Imaging studies
The morphologic changes can be found on plain radiography, CT scan or MRI. Radiologists try to describe the imaging appearance and the criteria that have been proposed as diagnostic signs of this condition. Some of these signs are subtle and can be easily missed, thus awareness of the examiner is very important. One recent study showed that 87% of patients that underwent surgery for labral tears had a structural hip abnormality identified on plain radiographs [8].

1. Plain Radiography
Plain X-ray is the most important imaging study for the diagnosis of impingement. The recommended views are a standard standing AP view of the pelvis and a cross-table lateral view of the hip in 15° of internal rotation. The standard AP pelvic x-ray [5] is one on which the coccyx points toward the symphysis pubis with a distance of no more than 2 cm between them and with symmetrical teardrops, obturator foramina, and iliac wings.

- **Retroversion of the acetabulum**

Retroversion of the acetabulum is the posterior orientation of the acetabular opening in relation to the sagittal plane. When the acetabulum is retroverted, the anterior and anterolateral portion of the acetabulum and acetabular labrum are located more laterally than normal and are obstacle to normal internal rotation and flexion. On cross-sectional imaging (CT or MRI), retroversion can be identified if the anterior rim of the acetabulum is lateral to the posterior rim on the first axial image that includes the femoral head [15]. Two radiographic signs indicating the retroversion of the acetabulum are:
- **Posterior wall sign**: In the true AP view of a normal hip, the edge of the posterior wall may be at or even lateral to the center of the femoral head. In a retroverted hip the posterior wall is seen medial to the center of the femoral head.
- **Cross-over sign** (Fig-1): Typically on a standard AP radiograph the lines of anterior and posterior walls are separated by 1.5 cm, however, retroversion will cause these two lines to intersect, usually in the superior half of the acetabulum.

Fig-1. Cross-over sign

- **Synovial herniation pits**

The synovial herniation pits were originally described in 1982 [9] with no appreciated causal relationship with FAI. These pits are often located in the anterolateral portion of the femoral head-neck junction. They show as regions of decreased bone density with well-defined margins and may cause a hot spot on bone scan. High prevalence of these cysts (33%) is reported in patients with FAI [16].

- **Pistol grip deformity**

A pistol-grip deformity is characterized by flattening of the usually concave surface of the femoral head, a bump on the anterolateral surface of the femoral neck, a so-called medial hook at the medial head-neck junction, and failure of the femoral head to be centered over the femoral neck. This name was attributed by Stulberg et al [2] due to its similarity with the smooth hand-grip of some pistols. Sometimes this sign is not perceptible in the AP X-ray and exhibit itself only in true lateral view.

- **Measuring the head-neck offset** (Fig-2, A=abnormal, B=normal)

It can be measured quantitatively on a true lateral X-ray or cross section CT or MRI by drawing three parallel lines: a line bisecting the longitudinal axis of the femoral neck (not necessarily through the center of the femoral head) another

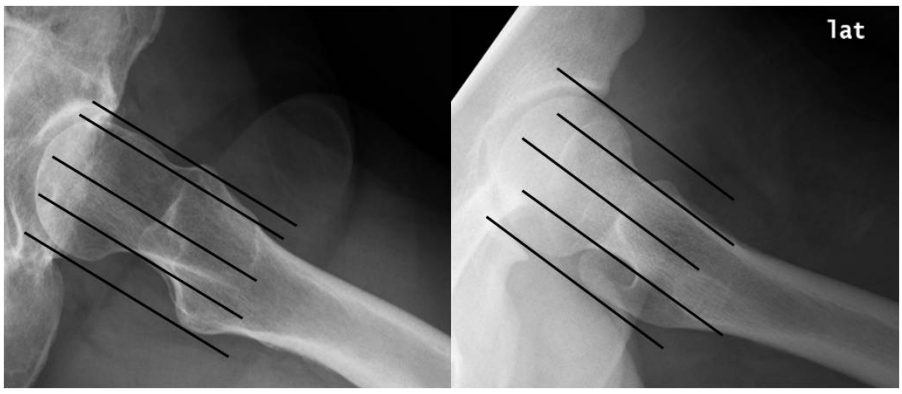

Fig-2. A and B Head Neck Offset

line tangential to the anterior aspect of the femoral neck, and a third one tangential to the anterior aspect of the femoral head. The perpendicular distance between the lines tangential to the neck and the anterior aspect of the head is defined as the head-neck offset, with normal being an absolute value of ≥9 mm or a ratio of the head diameter of ≥0.17.

- **Os acetabuli**

It is the result of ossification of both lateral acetabular rim and labrum due to repetitive impactions. This ossification further compromises the shock-absorbing feature of the acetabular labrum and may intensify the impingement.

- **Alfa angle** (Fig-3)

This angle is used as an objective representation of the prominence of the anterior femoral head-neck junction in the true lateral radiograph of the femoral neck with the cassette parallel to the femoral neck. It is also described in axial CT and MRI. An alpha angle of >50° appears to be abnormal in FAI [14]. It can typically be measured in a matter of seconds with a high degree of intraobserver and inter-observer agreement [13].

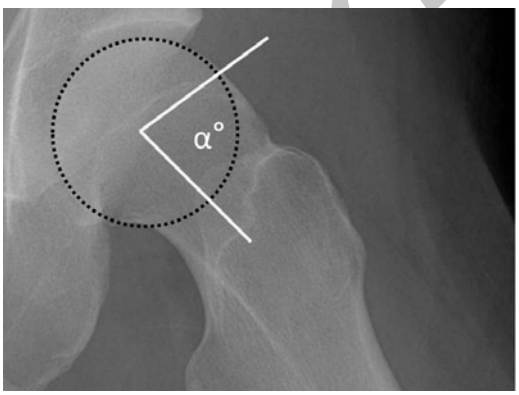

Fig-3. Alfa angle

2. Fluoroscopy

Flouroscopy of the hip can be used in equivocal cases to observe whether impingement occurs with dynamic motion of the hip and also for intraarticular injection of local anesthetic as a diagnostic measure.

3. CT Scan

Compared to plain radiographs and MRI, computed tomography has less commonly been used for diagnosis of FAI. 2-D and 3-D CT can be used to find the acetabular and femoral neck version, head-neck offset, and osseous deformity [6]. Occasionally multidetector CT arthrography of the hip can be utilized to evaluate labral pathology in patients who cannot undergo MRI procedures due to positive metal screening or significant claustrophobia.

4. MRI

Due to the deep location of hip joint and small intra-articular structures, this joint is difficult to image at MRI. Oblique imaging parallel to and through the middle of the femoral neck is the optimal view. A small field of view and the smallest possible slice thickness should be used in all cases [7]. Imaging time should be limited to less than 5 minutes per sequence to minimize patient's motion and associated blurring of the image. The interpreter's experience and familiarity with pathologic processes is essential.

MRI shows anterior and anterosuperior or anteroinferior acetabular labral damage. The damaged acetabular labrum shows increased signal on T2-weighted images that extends to the articular surface. This increased signal can either be well or ill-defined as is seen in linear and degenerative tears, respectively. Leunig et al [4] reported that the posterior acetabular labral damage was most likely to be located posterosuperiorly.

MR imaging is useful for demonstrating the damaged cartilage as well, which is primarily in the superolateral hip joint, either anterior or posterior, and usually close to the acetabular labral damage. The damaged part is seen as chondromalacia or partial/full-thickness cartilaginous defects. The cartilage damage is often associated with subchondral cyst formation, sclerosis, and osteophyte formation.

MR arthrography (with injection of gadolinium, lidocaine and normal saline) also is performed, especially if no pathology is seen on MRI or if an articular defect is suspected. This provides an optimal evaluation of the labrum and the articular cartilage. MR arthrography involves fluoroscopic guided intraarticular injection of the hip before MR imaging, and should not be confused with indirect MR arthrography, which relies on intravenous injection of gadolinium contrast with synovial uptake and diffusion into the joint.

Treatment Options

I. Nonsurgical

An initial trial of nonsurgical modalities including restriction or modification of the athletics activity, reduction of excessive motion and load on the hip, NSAIDs and physical therapy is recommended. Physical therapy emphasizes on muscle strengthening and prevention of extreme range of motion. Nonoperative measures will not eliminate the causal structural deformities. Persuading these young athletes to reduce or quit their sports activity is very difficult. Close follow-up of patients on nonoperative management is mandatory in order to intervene with surgery in suitable time and to prevent the progression of arthritis.

II. Surgical

Chronic symptoms without any response to nonoperative measures along with the imaging evidences of FAI and chondrolabral lesions are clear indications for operative intervention [1, 20]. The three introduced surgical options are open operation with surgical dislocation of the hip, arthroscopy, and arthroscopy combined with a limited open operation. Each one of these surgical approaches has its own advantages and drawbacks. The aims of surgery are alleviating femoral abutment against the acetabular rim, debridement of the hip, possibly repair of the labral tear, and osteoplasty of the femoral neck.

Surgical dislocation

This novel technique [22] allows broad visualization of the femoral head and acetabulum, better examination of the acetabular labral-chondral complex, and easier removal of the anterior acetabular bony overcoverage.Briefly it involves a posterior or preferably lateral incision, keeping the external rotator muscles intact, flip trochanteric osteotomy, anterolateral Z-shaped or alternatively T-shaped capsulotomy along the long axis of the femoral neck, incision of the ligamentum teres, anterior dislocation of the hip and resection of the offending structures. By carefully taking into consideration the course of the principal blood supply to the femoral head, profundus branch of medial femoral circumflex artery[21], and meticulous surgery, the danger of the avascular necrosis would virtually be avoided. Before dislocation and after the osteoplasty, the joint must be thoroughly examined throughout the physiologic ROM to confirm the site of abutment and the consequence of surgery and to see if there is any further problem that has to be addressed.

The shortcomings of this method are the probability of trochanteric nonunion, concerns about the long-term sequelae of dividing the ligamentum teres which has nerve endings similar to the cruciate ligaments of the knee, possible necessity of hard wear removal and the need for extended period of protected weight bearing.

Arthroscopy

Systematic total visualization of the central and the peripheral compartments of the hip is an essential part for the appropriate arthroscopic management of FAI. Arthroscopy of the hip can be performed in supine or lateral position [27, 28]. A distraction of at least 10-15 mm is required for adequate visualization and to easily introduction and maneuver the operating instruments in the joint [29]. Meanwhile the duration of the traction should be minimized to reduce the risk of nerve injury.

Tear in the labrum and chondral delamination are addressed using radiofrequency probes. Osteoplasty of the head-neck junction is performed by power burr. Labral resection should be conservative. Preservation of any healthy labral tissue may improve the overall integrity of the hip joint. In areas of exposed subchondral bone, a microfracture technique, chondroplasty or drilling may be performed to stimulate a fibrocartilaginous response [25, 30].

If the patient has a mixed or pincer type of impingement, a knife is used to take down the labrum from the anterior acetabular wall and then the anterior wall is recessed with an arthroscopic osteotome or burr. The amount of bone resected is typically 5 to 7 mm. Once this has been accomplished the labrum is sutured back over suture anchors using arthroscopic knot tying techniques through the latest version of transparent cannulae [29, 23]. Krueger et al [37] in second look arthroscopy after previous open hip dislocation and osteoplasty of the patients noticed that all reattached labra were stable.

Although compared to open dislocation, hip arthroscopy offers a minimally invasive approach with less morbidity and quicker recovery there are some drawbacks that have limited the acceptance and use of this procedure to simple cases [25]. Overall, the procedure is technical demanding, the space for proper manipulation of the instruments is restricted, the access for resection of the bony hump in the posterior parts is highly limited, there is potential for osseous debris to become entrapped in the joint, stable reattachment of the labrum is hard to do , little can be done to treat the chondral lesions, and finally complications such as tractional nerve palsies, foot or perineal pressure sores, RSD, instrument breakage, and iatrogenic damage to the articular cartilage of the joint are real [26].

Combined arthroscopy limited open operation

Because of some concerns about inadequate exposure and suboptimal reconstructions with arthroscopy, Clohisy et al [17] combined arthroscopic and mini-incision approach. The hip joint can first be visualized by hip arthroscopy, and an appropriate degree of osteoplasty can be carried out, subsequently the limited open procedure, with use of the Smith-Petersen interval and without dislocation of the hip for completion of the remaining osteoplasty and labral repair is done. This procedure is not advocated for hips with posterior impingement or circumferential lesions of the femoral head [32].

Alternatively a modified anterior Smith-Petersen mini approach can be used for the treatment of FAI [18, 26], although it still lacks the ability to address chondral lesions in the acetabulum, it adequately allows femoral neck osteoplasty, labral repair, and microfracture techniques through a small (6 cm) incision, therefore trochanteric osteotomy and all the inherent associated problems can be avoided.

Osteoplasty

Generally, resection of the hump to restore the normal head-neck offset is 5 to 7 mm deep and 8 to 12 mm wide [31] and should not exceed 30% of the anterolateral quadrant of the head-neck junction, otherwise the risk of femoral neck fracture increases [24]. There is no answer about the amount of the femoral neck that can be resected before vascular compromise occurs. However, care must be taken to avoid resection in the region of lateral epiphyseal vessel penetration.

Osteotomies

Occasionally owing to the osseous deformities, Bernie's periacetabular or femoral osteotomy is done to reorient the retroverted acetabulum and restore normal neck-shaft angle or version of the femoral neck respectively.

Discussion

Two surgically observed evidences support the concept that acetabular chondral lesions lead to labral damages rather than the reverse; first the occurrence of the labral damages at the articular not capsular margins, and second frequently encountered chondral lesions without labral damages at the very early stages of the impingement. Solitary labral damages arising from an acute traumatic event are rare. Despite the symptoms and clinical examinations in some cases suggestive of a traumatic nature of the labral tear, in fact it is the underlying impingement, however subtle, that leads to labral tear as part of a more extensive injury [26]. High association and same locations of labral and chondral injuries seen arthroscopicly in more than 400 patients by McCarthy [34] supports this concept to a large extent.

Thus far, short and medium-term results of open or arthroscopic surgical intervention for FAI and reverse periacetabular osteotomy for retroverted acetabulums are promising [33, 30, 36, 38, 39], but long-term effect on prevention of osteoarthritis in the future is not yet available. Adherence to the surgical tips of open dislocation is necessary to significantly reduce the rate of the osteonecrosis even to zero[12, 22, 33, 35]. Apparently the status of the articular cartilage is the major determinant of the ultimate outcome of any surgical technique, and resection of the labrum or moderate to severe joint space loss (Tönnis grade III or more) leads to inferior outcomes [30, 34].

Persistent pain after surgical dislocation of the hip without evidence of cartilaginous and osseous alterations may be due to intra-articular adhesions, so if the adhesions can be released, good results can be achieved [37]. Hip arthroscopy after previous surgery can be demanding because of scarring.

Our knowledge about FAI is in its infancy period and future improvements of imaging, arthroscopic and surgical techniques are on the way.

References

1. Ganz R, Parvizi J, Beck M, et al. Femoroacetabular impingement: a cause of osteoarthritis of the hip. *Clin Orthop*. 2003; 417:112.

2. Stulberg SD, Cordell LD, Harris WH, Ramsey PL, McEwen GD. Unrecognized childhood hip disease: a major cause of idiopathic OA of the hip. In: Proceedings of the 3rd meeting of the Hip Society. St Louis:Mosby;1975. p 212–28.

3. Eijer H, Myers SR, Ganz R. Anterior femoroacetabular impingement after femoral neck fractures. *J Orthop Trauma.* 2001;15:475–481.

4. Leunig M, Werlen S, Ungersbock A, Ito K, Ganz R. Evaluation of the acetabular labrum by MR arthrography. *J Bone Joint Surg Br.* 1997;79:230–4.

5. Meyer DC, Beck M, Ellis T, Ganz R, Leunig M. Comparison of six radiographic projections to assess femoral head/neck asphericity. *Clin Orthop Relat Res*. 2006;445:181-5.

6. Tannast M, Kubiak-Langer M, Langlotz F, et al. Noninvasive three-dimensional assessment of femoroacetabular impingement. *J Orthop Res*. 2007;25:122

7. Kassarjian A. Hip MR Arthrography and Femoroacetabular Impingement. *Semin Musculoskelet Radiol*. 2006;10:208–219.

8. Wenger DE, Kendell KR, Miner MR, et al. Acetabular labral tears rarely occur in the absence of bony abnormalities. *Clin Orthop Relat Res.* 2004;426:145–50.

9. Pitt MJ, Graham AR, Shipman JH, et al. Herniation pit of the femoral neck. *Am J Roentgenol* 1982;138:1115–21.

10. Beall DP, Sweet CF, Martin HD, Lastine CL, Grayson DE, Ly JQ, Fish JR. Imaging findings of femoroacetabular impingement syndrome. *Skeletal Radiol*. 2005; 34:691-701.

11. Burnett RS, Della Rocca GJ, Prather H, Curry M, Maloney WJ, Clohisy JC. Clinical presentation of patients with tears of the acetabular labrum. *J Bone Joint Surg Am.* 2006;88:1448-57.

12. Jäger M, Wild A, Westhoff B, Krauspe R. Femoroacetabular impingement caused by a femoral osseous head-neck bump deformity: clinical, radiological, and experimental results. *J Orthop Sci*. 2004;9:256-63

13. Kassarjian A, Cerezal L, Llopis E. Femoroacetabular Impingement. *Top Magn Reson Imaging*. 2006;17(5):337- 45

14. Nötzli H, Wysss T, Stoecklin C, Schmid M, Treiber K, Hodler J. The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. *J Bone Joint Surg Br.* 2002;84:556-560.

15. Reynolds D, Lucas J, Klaue K. Retroversion of the acetabulum: A cause of hip pain. *J Bone Joint Surg Br.* 1999; 81:281Y288.

16. Leunig M, Beck M, Kalhor M, et al. Fibrocystic changes at anterosuperior femoral neck: prevalence in hips with femoroacetabular impingement. *Radiology*. 2005;236:237-246.

17. Clohisy JC, McClure JT. Treatment of anterior femoroacetabular impingement with combined hip arthroscopy and limited anterior decompression. *Iowa Orthop J.* 2005; 25:164-71.

18. Jaberi FM, Parvizi J. Hip Pain in Young Adults: Femoroacetabular Impingement. *J Arthroplasty*. 2007;22(7); Suppl 3:37-42.

19. Philippon MJ, Maxwell RB, Johnston TL, Schenker M, Briggs KK. Clinical presentation of femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc*. 2007; 15(8):1041-7.

20. Crawford JR, Villar RN. Current concepts in the management of femoroacetabular impingement. *J Bone Joint Surg Br*. 2005;87:1459-62.

21. Gautier E, Ganz K, Krugel N, Gill T, Ganz R. Anatomy of the medial femoral circumflex artery and its surgical implications. *J Bone Joint Surg Br*. 2000;82:679-683

22. Ganz R, Gill TJ, Gautier E, Ganz K, Krugel N, Berlemann U. Surgical dislocation of the adult hip: A technique with full access to femoral head and acetabulum without the risk of avascular necrosis. *J Bone Joint Surg Br*. 2001; 83:1119-24.

23. Philippon MJ, Schenker ML. A New Method for Acetabular Rim Trimming and Labral Repair. *Clin Sports Med*. 2006;25:293–297.

24. Mardones RM, Gonzalez C, Chen Q, Zobitz M, Kaufman KR, Trousdale RT. Surgical treatment of femoroacetabular impingement: evaluation of the effect of the size of the resection. *J Bone Joint Surg Am*. 2005;87:273-9

25. Guanche CA, Bare AA. Arthroscopic treatment of femoroacetabular impingement. *Arthroscopy*. 2006;22:95-106

26. Parvizi J, Leunig M, Ganz R. Femoroacetabular Impingement. J Am Acad Orthop Surg. 2007;9:561-570.

27. Byrd JW. Hip arthroscopy utilising the supine position. *Arthroscopy*. 1994;10:275–280.

28. Glick JM, Sampson TG, Gordon RB, Behr JT, Schmidt E. Hip arthroscopy by the lateral approach. *Arthroscopy*. 1987;3:4–12.

29. Khanduja V, Villar RN. The arthroscopic management of femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(8):1035-40.

30. Sampson TG. Arthroscopic treatment of femoroacetabular impingement. *Tech Orthop*. 2005;20:56-62.

31. Philippon MJ, Stubbs AJ, Schenker ML, Maxwell RB, Ganz R, Leunig M. Arthroscopic Management of Femoroacetabular Impingement: Osteoplasty Technique and Literature Review. *Am J Sports Med*. 2007; 35(9):1571-80.

32. Maheshwari AV, Malik A, Dorr LD. Impingement of the native hip joint. *J Bone Joint Surg Am*. 2007;89(11): 2508-18.

33. Beck M, Leunig M, Parvizi J, Boutier V, Wyss D, Ganz R. Anterior femoroacetabular impingement: part II. Midterm results of surgical treatment. *Clin Orthop Relat Res*. 2004:418:67-73.

34. McCarthy JC, Noble PC, Schuck MR, Wright J, Lee J. The role of labral lesions to development of early degenerative hip disease. *Clin Ortho.p* 2001;393:25.

35. Murphy S, Tannast M, Kim YJ, Buly R, Millis MB. Debridement of the adult hip for femoroacetabular impingement: indications and preliminary clinical results. *Clin Orthop Relat Res*. 2004;429:178-81.

36. Siebenrock KA, Schoeniger R, Ganz R. Anterior femoro-acetabular impingement due to acetabular retroversion. Treatment with periacetabular osteotomy. *J Bone Joint Surg Am*. 2003;85:278-86

37. Krueger A, Leunig M, Siebenrock KA, Beck M. Hip arthroscopy after previous surgical hip dislocation for femoroacetabular impingement. *Arthroscopy*. 2007;23(12):1285-1289.

38. Stähelin L, Stähelin T, Jolles BM, Herzog RF. Arthroscopic offset restoration in femoroacetabular cam impingement: accuracy and early clinical outcome. *Arthroscopy*. 2008;24(1):51-57.

39. Beaulé PE, Le Duff MJ, Zaragoza E. Quality of life following femoral head-neck osteochondroplasty for femoroacetabular impingement. *J Bone Joint Surg Am*. 2007;89 (4):773-9.

.