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POSITIONING OF ACETABULAR AND FEMORAL COMPONENT IN PRIMARY TOTAL HIP ARTHROPLASTY USING CT EVALUATED PATIENT NATIVE ANATOMY

Orthopaedics

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ABSTRACT

In total hip arthroplasty, component orientation is an important task for stability. Acetabular and femoral component orientation is the key factor for outcome of total hip arthroplasty. The aim of this study is to assess the clinical and radiological effectiveness of positioning of acetabulum and femoral components in primary total hip replacement using CT evaluated patient native anatomy. Subjects of this study were 36 patients with non-union neck of femur fractures or arthritic hip based on inclusion and exclusion criteria and treated with cemented or uncemented total hip arthroplasty. Pre operative CT scan with 3D reconstruction was done for all patients and the acetabular inclination and version was measured in coronal and axial planes. Femoral anteversion was measured in mid axial image. Transverse acetabular notch (TAN) and anterior acetabular notch (AAN) were identified intra operatively to reproduce the pre operative angles. Post operatively CT scan was done and all angles were measured as before. All patients were followed up and analyzed using Harris Hip Score. The mean preoperative Harris Hip Score is 34.5. The mean postoperative Harris Hip Score is 88.19. Mean acetabular cup inclination is 39.80°, Mean cup anteversion is 15.1° and mean femoral anteversion is 14.75°. No Dislocation was noted during follow up. No hips show clinical and radiological evidence of femoral and acetabular component loosening. All Postoperative CT measurements of angles are within the safe zone by Lewinnek et al. Preoperative CT guided parameters, intra operative anatomical landmarks (TAN&AAN) and the digital protractor device can aid better positioning of the acetabular and femoral component of THA and is independent of the position of the patient. It also provides a precise planning for component placement resulting in less intra operative time thereby reducing the chances of infection and decreases the dislocation rate and wear and tear and improves the functional outcome.

KEYWORDS

TAN, AAN, Acetabular anteversion and abduction, femoral anteversion angles, digital protractor device

INTRODUCTION:

The primary aim of total hip arthroplasty is to create a stable, functional, painless hip. In arthroplasty, component orientation is an important task for stability. Acetabular and femoral component orientation is the key factor for outcome of total hip arthroplasty. Dislocation, wear and tear, loosening are the major complications after total hip arthroplasty.

Among numerous factors influencing dislocation, component malposition is an important factor under the control of the surgeon. Conventionally, Transverse acetabular ligament (TAL) is used as a landmark for acetabular cup positioning and lesser trochanter for femoral stem positioning. The ligament is identified only in 47% during surgery and cup position was not improved using the ligament as reference.

Mechanical guides and computer assisted navigation systems have been designed to improve proper cup positioning. The use of mechanical guides still results in large variations in cup orientation. Computer-Assisted Navigation system is ongoing, not available in all centres. Therefore, a simple, practical, and anatomically based alignment method to position the acetabular cup and femoral stem is needed.

The purpose of this study is to align and position the acetabular and femoral components using anatomical landmarks and place the components within the safe zone by preoperative CT measurements on normal hip and to evaluate the dislocation rate and functional outcome.

Procedure:

In the normal pelvis, the transverse acetabular notch (TAN) at the lower margin and the anterior acetabular notch (AAN) on the anterior rim halfway between the TAN and the opposite point on the superior rim are the two notches on the acetabular rim.

The TAN, a proxy of the inferior pole of the acetabular cup, could be used as an intraoperatively identifiable landmark to align cup abduction and the AAN, a proxy of the anterior pole of the acetabular cup, as a landmark to align cup anteversion.

TAN appears as the teardrop in the mid-coronal image of the reconstructed CT scan and the AAN at the anterior point in the mid axial image. The angle between a line drawn from the acetabular teardrop to the lateral acetabular margin and the inter teardrop line on the mid coronal image, gives acetabular abduction. The angle between a line

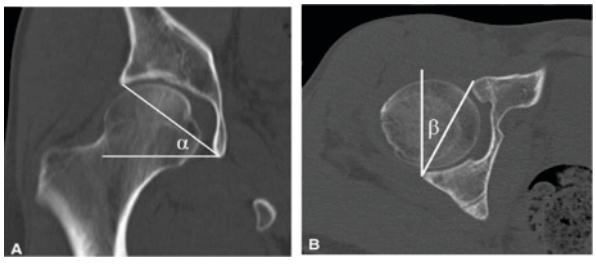

Figure 1 abduction and anteversion angles

drawn from the anterior to the posterior acetabular margin and a line perpendicular to the line connecting the centres of both femoral heads on mid axial image, gives acetabular anteversion. In osteoarthritis of hip, the osteophytes found in the anterior rim of the acetabulum, obscure the AAN, and a bony spur covers the cotyloid fossa, the so-called central osteophyte, which obscures the TAN hence the measurement was taken from the true margin of the acetabulum excluding the osteophytes. Femoral anteversion: Measured in Mid axial image. Angle between long axis of femoral neck and condylar axis of femur. Angle between long axis of femoral neck and line parallel to dorsal aspect of femoral condyle. In preoperative CT measurements, each degree of angle measurement corresponds to one mm of cup alignment.

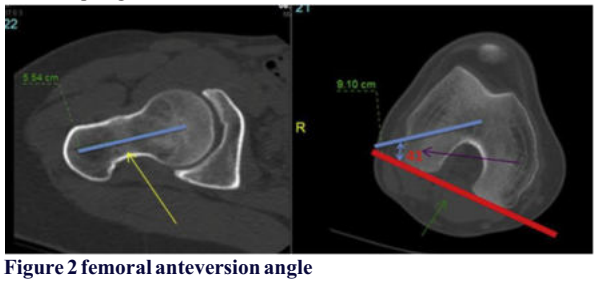

Figure 2 femoral anteversion angle

Acetabular component placement:

Digital Protractor Angle Device:

Reaming of acetabulum starts with smallest size of reamer. In this technique, anteversion and inclination of components are accurately placed using this protractor device. The index point of the protractor is placed on the table at the level of patient's hip. Measured angle is created at the device by adjusting its vertical limb. Acetabulum reamer

is kept over the acetabulum and holding device of the reamer is kept parallel to vertical limb of the protractor. The anteversion angle is adjusted according to the anterior and posterior notch points of the acetabulum. Subsequent acetabular reaming is done keeping the reamer parallel to protractor device until fresh bleeding of acetabulum. Anatomical landmarks over the acetabulum are reidentified and marked. Cup abduction is adjusted between superior and inferior points and anteversion is adjusted between anterior and posterior points. Each mm of component is adjusted based on preoperative inclination and anteversion angles corresponding to the acetabular anatomical landmarks. Trial component of acetabulum is placed corresponding to landmarks and angle protractor device. Acetabulum drying is done, and cemented cups are inserted after cementation of acetabulum and the edge of the cup is adjusted corresponding to the landmarks and the cup holding device is adjusted according to the protractor device.

Femoral Component Placement:

Posterior femoral condyle part of femur is anatomical landmark for femoral component anteversion positioning. Tibia is kept perpendicular to the floor. During rasping of femoral canal, anteversion of the femoral component is made corresponding to the posterior femoral condyle and the lesser trochanter and checked with protractor device with desired angle. After component positioning, reproduction of cup and femoral stem anteversion is checked by combined version of Ranawat method.

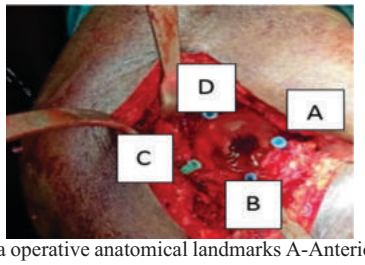

Figure-3 intra operative anatomical landmarks A-Anterior acetabular notch, B-Transverse acetabular notch Transverse Acetabular Notch (TAN)(B) is taken as inferior point and Anterior Acetabular Notch (AAN)(A) is taken as anterior point. Opposite to Transverse Acetabular Notch(B) in superior border is considered as Superior point(D). Opposite to Anterior Acetabular Notch(A) (anterior point) in posterior border is considered as posterior point(C)

Figure-4 digital protractor angle device- the index point of the device is at the level of the operating hip, acetabular reamer and cup holding device are held parallel to the vertical limb of the device

MATERIALS AND METHODS:

Subjects of this study were 36 patients with non-union neck of femur fractures or arthritic hip based on inclusion and exclusion criteria and treated with cemented or uncemented total hip arthroplasty. Pre operative clinical examination, Harris Hip score, X-ray pelvis with both hips AP and cross table lateral view of affected hip and CT scan with 3D reconstruction was done for all patients and the acetabular inclination and version was measured in mid coronal and mid axial planes. The least involved side was taken as reference in bilateral hip involvement.

Femoral anteversion was measured in mid axial image. Transverse acetabular notch (TAN) and anterior acetabular notch (AAN) were identified intra operatively and digital protractor device to reproduce the pre operative angles. Post operatively CT scan was done and all angles were measured as before. All patients were followed up and analyzed using Harris Hip Score.

RESULTS:

The outcome of Total Hip Arthroplasty by this method is measured by Harris Hip Score. The mean preoperative Harris Hip Score is 34.5. The mean postoperative Harris Hip Score is 88.19. No deterioration in follow up Harris Hip Score. Mean acetabular cup inclination is 39.80°, Mean cup anteversion is 15.1° and mean femoral anteversion is 14.75°. No Dislocation was noted during the follow up.

No hip show clinical and radiological evidence of femoral and acetabular component loosening. No wear and tear of components. All Postoperative CT measurements of angles are within the safe zone by Lewinnek et al. One patient had Superficial skin infection in this study, treated with IV antibiotics and secondary suturing. Anterior and lateral thigh pain noted in two patients treated with analgesics and the patients are under follow up.

Table 1: Anteversion angle of acetabulum

	Minimum	Maximum	Mean	STD error of Mean	Standard deviation	Median	Mode
Pre op	8	24	16.05	0.5	3.35	16	16
Post op	13	22	15.1	0.23	1.43	15	15

P value: 0.028111 [significant]

Table 2: Abduction angle of acetabulum

	Minimum	Maximum	Mean	STD error Of Mean	Standard deviation	Median	Mode
Preop	31	52	39.74	0.5	3.1	39	39
Post op	36	46	39.8	0.177	1.06	40	40

P value: 0.045436 [significant]

Table 3: Anteversion angle of femur

	Minimum	Maximum	Mean	STD error Of Mean	Standard deviation	Median	Mode
Preop	6	23	15.32	0.16	4.1	16	16
Post op	12	18	14.75	0.24	1.46	15	15

P value: 0.03228 [significant]

Mean preoperative acetabulum anteversion is 16.05 and mean postoperative acetabulum anteversion is 15.1. Mean preoperative abduction angle of acetabulum is 39.74 and mean postoperative abduction angle is 39.8. Mean preoperative anteversion of femur is 15.32 and mean post-operative anteversion of femur is 14. 75. By this method, the postoperative acetabular version and inclination and femoral version were found to be near normal preoperative values and lie within the normal range and within the safe zone proposed by Lewinnek et al.

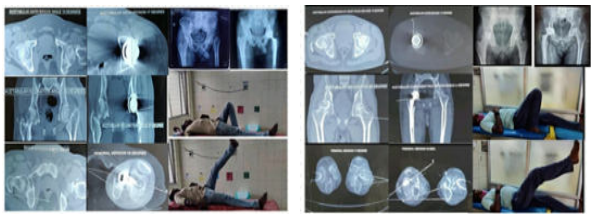

Figure 5 case illustration 1&2

DISCUSSION:

Proper positioning of the acetabular cup has been a challenging issue of THA. Acetabular component must be placed correctly in all planes like sagittal, coronal and axial. Extreme mediolateral positions affect the lever arm forces and the joint reaction force. Proper placement of components is important for stability and survival ship of implant. Certain general factors influencing the cup position are increased BMI, position of the patient, pelvic orientation, surgical approach, surgeon experience, inaccuracy, and inadequacy of mechanical guides.

Archbold et al proposed the transverse acetabular ligament and labrum as a reference to guide height, depth and anteversion of the cup. When the ligament was used as reference, the cup was not in safe zone due to difficulty in identifying the ligament as it is found only in 47%. This study does not give significant parameters to inclination of the cup. There are various studies which include transverse acetabular ligament for aligning acetabular component in total hip arthroplasty.

The mechanical guides have been designed for proper cup positioning. Alignment of the cup regarding the longitudinal and coronal planes of the patient are being done using mechanical intraoperative devices.

But individual variations with respect to patient's anatomy or the change in orientation of pelvis during operation are not being considered by these devices. The use of mechanical guides has reported inadequate cup orientation beyond desired alignment in high percentage. Digioia et al showed a mechanical guide was inadequate in achieving the desired anteversion angle and, to a lesser extent, the abduction angle; among 74 impacted press-fit cups using the guide, 78% had an unacceptable acetabular alignment. The navigation systems including the extra costs, additional radiation exposure, time-consuming preoperative planning, intraoperative matching procedures, and availability issues. Therefore, we created a simple, practical, and anatomically based alignment and positioning of components. The purpose of this study was to determine the accuracy of our method in cup inclination and anteversion and femoral anteversion and to calculate the dislocation rate and functional outcome of THA after use of our method. In our study of 36 cases, 23 were male and 13 were female. The mean age of patients in our study was 56.5 and were followed for a period of 6 months. The mean preoperative Harris Hip Score was 34.5. The mean postoperative Harris Hip Score was 88.19. Mean acetabular cup inclination is 39.80°, Mean cup anteversion is 15.1° and mean femoral anteversion is 14.75°. All were found to lie within the safe zone as proposed by Lewinnek et al. The dislocation rate is zero. Out of 36 patients, 11 had excellent [30.5%], 21 had good [58.33%], 3 had fair [8.33%] and 1 had poor outcome [2.77%].

CONCLUSION:

Acetabular cup and femoral component placement remain an important factor in the outcome of total hip arthroplasty which influences the dislocation rate, wear rate, loosening, impingement, patient outcome.

Preoperative CT guided parameters, intra operative anatomical landmarks to aid alignment and the digital protractor device can aid better positioning of the acetabular and femoral component of THA and is independent of the position of the patient. It also provides a precise planning for component placement resulting in less intra operative time thereby reducing the chances of infection and decreases the dislocation rate and wear and tear and improves the functional outcome. By conventional method, the postoperative dislocation rate is 10% which is reduced to zero by using this method. Hence this method is proved to be efficient in component placement and cost effective.

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