

# Factors affecting demonstration of intra-operative Coplanar test in Total Hip Arthroplasty

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## Abstract

**Context:** Coplanar test measures intraoperative value of combined anteversion of femoral and acetabular components .

**Aim:** Purpose of this study was to investigate factors affecting demonstration of Coplanar test when the combined anteversion (CA) was kept within the safe zone in uncemented total hip arthroplasty (THA) in posterior approach .

**Settings and Design:** It's a prospective study design conducted in a tertiary care health centre.

**Methods and Material:** We analysed 80 cases of primary uncemented THA between October 2015 to Dec 2016 . Pre-operatively, we measured height of all patients and mid -thigh circumference . Transverse acetabular ligament was used as a reference for acetabular anteversion and implantation . We were able to demonstrate the coplanar test in 58 patients . Analysis of correlation of coplanar test with thigh circumference , height of the patient , Neck shaft angle of femoral stem and abduction angle of acetabular component was done .

**Statistical analysis used:** Baseline Data were described in mean and Interquartile Ratio compared to non parametric test. Pearson chi square test for correlation of abduction angle and neck shaft angle with coplanar test. Levene test for correlation of thigh circumference and height of the patient. Multiple logistic regression analysis for all factors .

**Results:** Inclination of cup and thigh circumference were statistically significant independent factors which could affect the test demonstration .

**Key words:** Co-planar test , Combined anteversion , uncemented total hip replacement , Ranawat coplanar test.

## Introduction

Recreation of stable joint with good range of movement is the primary goal of total hip arthroplasty [1].

Impingement free range of motion (ROM) of a total hip replacement depends on the various parameters such as the inclination , anteversion of acetabular component and stem anteversion and cup containment [2-4] . Incorrect implant positioning leads to complications like dislocations, decreased range of motion, poly wear and loosening [5]. Impingement of

prosthetic femoral neck over acetabular rim /poly is one of the main causes of dislocation . Thus, implant positioning is the most critical factor influencing the outcome of total hip arthroplasty[6-8]. The concept of combined anteversion ( sum of acetabular anteversion and femoral anteversion ) has been proposed so as to quantify the prosthetic alignment [9]. C S Ranawat in 1991 proposed the co planar test to intraoperatively assess the combined anteversion of femoral component and acetabulum when cemented sockets were used [10]. Coplanar test measures intraoperative value of combined anteversion of femoral and acetabular components. If implants are fixed within the safe range of combined anteversion, it is proven that impingement of prosthesis will not occur and hence

decreased chance of dislocation. Safe zone of combined anteversion has been shown as  $40^{\circ} \pm 15^{\circ}$  [7,9] Coplanar test was described in 1991 by Ranawat et al . Several authors have expressed their concerns regarding combined anteversion [11,12] but no investigator has revisited the co -planar test and went into details of factors affecting the test. This test was initially described for cemented sockets. However it is commonly taken as a guide for assessing intraoperative combined anteversion in both cemented and uncemented sockets when using posterior approach for THR . We hypothesize that the coplanar test depends upon multiple patient related and implant related factors apart from anteversion of acetabulum.

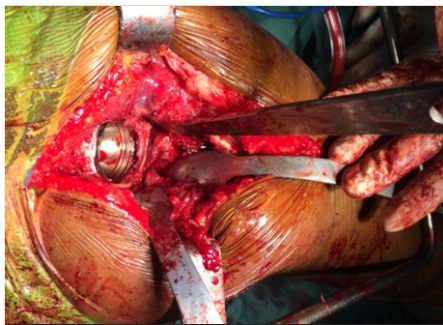
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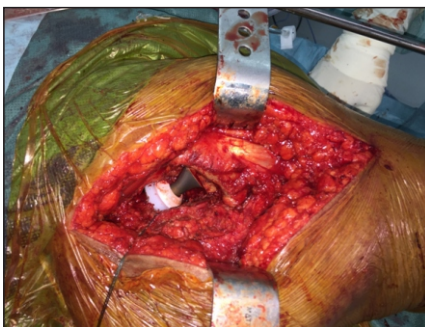
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**Figure 1:** Transverse acetabular Ligament parallel to cup.



**Figure 2:** Co-planar test Positive.



**Figure 3:** Combined anteversion Angle.

**Materials and Methods**

We analysed 80 cases of primary uncemented Total Hip Arthroplasty between October 2015 to Dec 2016. There were 48 male patients and 32

female patients. The reason for surgery was neck of femur fracture 26 in patients, Arthritis of hip in 24 patients (Rheumatoid and primary osteoarthritis), avascular necrosis of hip in 14 patients, failed fixation of neck

Femur fracture in 9 patients, ankylosing spondylitis in 2 patients and 5 patients had dysplastic hip. Patients with type 1 defects of femur where we had used diaphyseal fitting stem were excluded from study. We have used implants of 2 different makes :Stryker and Zimmer. In accolade stem (Stryker) we have used two variants; standard (132°) and (127°)high offset depending upon soft tissue migration and to prevent impingement. In Zimmer , we have used two types of stems : CLS Stem and ML taper stem , both have same neck shaft angle 135°. We grouped patients into three groups for correlation of neck shaft angle. Group 1 ; - 127° ,Group 2;- 132°, Group 3;- 135°. Pre-operatively, we measured height of all patients and mid -thigh circumference of operative leg at 20 cm above the superior pole of patella. All patients were operated by Moore Approach with patient in lateral position . Pillow was not kept between thighs in any of the patient. Acetabular preparation was done first.Transverse acetabular ligament (TAL) was visualized in all patients .Transverse acetabular ligament was

used as a reference for acetabular anteversion (Fig 1). Cup was implanted in such a way that TAL was completely seen below the lower margin of the cup . We tried to implant the cup flush with TAL. We could do in maximum percentage of our cases .We excluded those cases where cup placement was not parallel to TAL . Each time after implanting the prosthesis before capsular closure we tried to demonstrate co-planar test (Fig 2). We took pictures of demonstrated co-planar test and at whatever angle it was demonstrated. We excluded those cases where cup was not parallel to TAL. Various studies have shown that TAL is an independent indicator of anteversion of acetabular component independent of position of patient. [14-17] Angle of implantation was based on OT table surface for inclination. We made all patients into three groups of acetabular inclination angle for comparison and for statistical correlation. Group 1 -30°- 40°, Group 2 ; - 41°-50°, Group 3 ; - >50°. The Combined Anteversion was assessed by rotating the hip at neutral flexion to a position where the prosthetic neck is perpendicular to the face of the acetabular socket . At this position ,the amount of internal rotation was recorded [10] (Fig3) . We were not able to demonstrate the coplanar test in 22 patients. Patients were analysed radiographically for cup inclination , implant positioning and the neck shaft angle of different stems.

**Results**

Demographic data			
Age Group	Gender		Total
	Male	Female	
1-45	4	1	7
46-60	0	7	1
61-75	5	0	5
>75	1	7	12
<b>Total</b>	<b>26</b>	<b>10</b>	<b>6</b>

Co planar test .			
Inclination Angle	Co planar test		Total
	Positive	Negative	
30-40°	4	1	7
41-50°	0	7	1
51-60°	5	0	5
>60°	1	7	12
<b>Total</b>	<b>26</b>	<b>10</b>	<b>6</b>

Table 3: Coplanar test and its relation to thigh circumference and height of the patient				
Co planar test	n	Mean Height (cm)	Mean Thigh Circumference (cm)	Mean
				Deviation
Positive	22	35.95	2.78	.594
	58	32.40	1.991	.261
Negative	22	156.50	7.190	1.533
	58	162.59	9.340	1.226

Neck shaft angle * Co planar test			
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shaft angle	دو و	و	و
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Co planar test			
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Table 5: Regression Analysis							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 <sup>a</sup>	Height of patient	.087	.056	2.421	1	.120	1.091
	Thigh circumference	-.660	.202	10.661	1	.001	.517
	Abduction angle	.197	.060	10.686	1	.001	1.218
	Neck shaft angle	-.164	.462	.126	1	.723	.849
	Constant	1.562	10.918	.020	1	.886	4.771
Step 2 <sup>a</sup>	Height of patient	.084	.055	2.318	1	.128	1.088
	Thigh circumference	-.649	.198	10.774	1	.001	.523
	Abduction angle	.191	.057	11.235	1	.001	1.211
	Constant	1.645	10.887	.023	1	.880	5.182
Step 3 <sup>a</sup>	Thigh circumference	-.673	.196	11.818	1	.001	.510
	Abduction angle	.201	.057	12.337	1	.000	1.223
	Constant	15.547	6.744	5.314	1	.021	5646790.005

We applied statistical methods for following data. 1) Males and Females 2) Height of individual. 3) Inclination angle. 4) Thigh circumference. 5) Neck shaft angle of prosthesis. The results of statistical analysis of each factors has been provided in detail in following tables. Table 1 to 5 The tests of normality Kolmogoro-Smirnov & Shapiro-Wilk tests were skewed for Thigh circumference and height of patients. Levene test was done for and Data were described in mean and IQR compared to non parametric test. There was statistically significant correlation with lesser abduction angle and negative coplanar test. Similarly with higher thigh circumference and negative coplanar test. In Group 1, where we had used 127 degree neck shaft angled stems had lower percentage of demonstration of co-planarity test as compared to patients in which we had used 132 and 135 degree stem. However, this was not found to be statistically significant to conclude. Multiple logistic regression analysis was performed to analyse the factors affecting the same. We found that inclination of cup and thigh circumference were statistically significant independent variables which could affect the test demonstration.

**Discussion**

Accurate positioning of cup depends on many factors. Proper exposure of acetabulum is the most important factor which dictates proper angle for

reaming and hence position of the cup. In posterior approach, in obese individuals iliotibial band restricts the cup being positioned more horizontal (less inclination angle). Increasing skin incision or offset reamer usage will help to position the cup in desired position. TAL itself obstructs the more horizontal cup positioning if exposure is not adequate. Anterior capsular release helps to have good exposure to acetabulum. Several authors have described regarding cup positioning in relation to TAL that cup positioned parallel to TAL will have ideal anteversion [16]. As discussed by many, anteversion cannot be manipulated or changed using uncemented stem to large extent [11,12]. In uncemented stem to achieve stable press fit, the stem must adjust to the femoral bone geometry, thus there is limited ability to change femoral anteversion when compared to cemented stem. For the same reason combined anteversion becomes more important in uncemented total hip arthroplasty [7,11,12]. Combined anteversion technique has been explained by Dorr et al, wherein they have done first Femur technique has been used to have ideal surfaces of bearing to have ROM without impingement [14]. According to study done by Lewinnek et al [11], the safe zone of acetabular cup inclination of 40+/-10 degrees with anteversion of

15+/-10 degrees. It was found that dislocation rates was increased to 4 times if the implant placement was outside this range. Similar results were shown in the studies done by Biedermann and Wixon et al [3,4]. In patients with failed fixation of fracture neck femur, in cases of contraction of hip capsule or in situation where we had difficulty in reduction of hip joint, we have used high offset (127degree) stem. With higher offset reduction of hip is easier as less traction is required and less chance of impingement. There is tendency to inability to demonstrate the test with higher offset stems. However there is no statistical significant correlation to prove the same. Inclination of acetabular shell is independent factor which is directly proportional to ability to demonstrate the test. As the abduction angle decreases the coplanar test becomes difficult. Non operative thigh of opposite side obstructs efforts to do more adduction in order to get test positive. In persons with lesser thigh circumference, the operative thigh can adduct more in front of other thigh crossing it and test can be made positive. In cases of lesser abduction angle of acetabulum group of 300-400 with high offset stem usage are the cases of high probability that coplanar test will not be demonstrated. Cup was placed in slight vertical orientation

(50- 55 deg) intentionally in 3 cases. Two in dysplastic and one in grade 4 AVN with lateral subluxated proximal Femur with superolateral acetabular wall insufficiency to have complete coverage. In these cases we had to abduct the thigh to get co-planar test positive. It is an indirect evidence and supports our hypothesis that inclination of socket is an independent variable for demonstration of co planar test. Original description of the co planar test was done for cemented cups [10]. In original article they have expressed that test gives false negative or inability to properly demonstrate the test in those cases of elevated liners of acetabulum. As most available liners in

different systems comes with elevated liners (lipped liners) it is not always possible to do test to confirm coplanarity if we are orienting the liner of acetabulum. If shell of acetabulum is overhanging the acetabular margin, socket margin of shell itself can be used to match with head to achieve coplanarity. Weakness of our study is that we have not quantified the anteversion angle of acetabulum. Previous articles have used computer assistance to quantify the anteversion and combined anteversion is assessed using navigation [3,11,14]. We conclude that it's a complex entity and involves multiple factors. Coplanar test is a good indicator of ideal prosthesis

placement, however inability to demonstrate the test in the absence of impingement of components is acceptable and will not have any adverse impact on long term survival of prosthesis. On table test to assess the angle of anteversion is a rough guide and in itself it is not an accurate yardstick of combined anteversion. Goal of our surgery should be to have impingement free range of movement of hip joint to prevent dislocation and to have maximum stability to the joint. Angle can vary with change of any one of these discussed factors and might preclude us from successful demonstration of the test.

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