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The orientation of acetabular component in total hip replacement using transverse acetabular ligament as a guide

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Abstract
Introduction: Acetabular component placement is a crucial determinant in outcomes following total hip arthroplasty. Malalignment predisposes to impingement, increased rate of dislocation, wear of the bearing, osteolysis, and revision after THA. The study aimed to determine how reliably the transverse acetabular ligament could be identified during primary THA and its validity as a guide for acetabular component placement within the safe zone in THA.
Materials and Methods: In this prospective study, 52 patients undergoing total hip replacement during the period from August 2014 to January 2017 in Bowring and Lady Curzon Hospital and Victoria Hospital, Bangalore were included; in whom the acetabular component positioning was done using transverse acetabular ligament as a guide. 22 cases were done via modified lateral approach, while 30 cases were done via posterolateral approach. Acetabular reaming was done by placing the reamer parallel to TAL, starting with a reamer the diameter of the native femoral head. Following serial reaming, the final component is placed such that TAL should embrace it. The anteversion and inclination/abduction of the acetabular component was measured post-operatively by anteroposterior radiographs.
Results: TAL was identified in all cases, irrespective of the surgical approach used. The mean planar anteversion was 19.84° (± 3.8°), and the radiological inclination was 43.65° (± 3.2°). Anteversion was within the safe zone in 96.15% (n=50) of the cases, while inclination was within the safe zone in 84.6% (n=44) of the cases.
Conclusion: Transverse acetabular ligament can be reliably used as a guide in achieving patient-specific anteversion of the acetabular component within safe zone. A simple, reproducible technique, devoid of complex instrumentation. However, as inclination is influenced by factors in addition to TAL, TAL alone cannot be used for determining inclination of acetabular component positioning.

Keywords: Total hip replacement, transverse acetabular ligament, cup placement, cup orientation, dislocation

1. Introduction
Various factors influence both short-term and long-term outcomes following total hip arthroplasty, of which acetabular component placement is a crucial determinant. The positioning of the acetabular component during primary THA remains a challenge and errors lead to instability and dislocations [1] leg-length inequality, impingement, excessive wear and osteolysis [2, 3], edge loading and occasional dissociation of the liner and its fracture [4].
Ideal placement of the acetabular component remains elusive both in terms of defining and achieving a target. The 'safe zone' of Lewinnek [10]. with abduction of 40° (30° to 50°) and anteversion of 15° (5° to 15°), has become accepted as a reference for orientation of the acetabular component.
There is a need for a technique that is universally plausible, reproducible, and consistent, with the least economic burden to the patient and the institute. There has been recent literature reporting that the transverse acetabular ligament (TAL) is helpful as an anatomical landmark in determining the position of the acetabular component in total hip replacement (THR) [1-3]. However, there is little published Indian literature on this technique. We intend to assess placement of the acetabular component based on TAL, and evaluate the acetabular component position based on anteversion and inclination in relation to the Lewinnek safe zone.

2. Patients and methods

Between August 2014 and January 2017, 52 consecutive patients underwent primary THA at Victoria Hospital and Bowring and Lady Curzon Hospitals attached to Bangalore Medical College and Research Institute. All the patients aged between 20 and 80 years who underwent primary total hip replacements following primary osteoarthritis of hip, or osteoarthritis secondary to inflammatory arthritis, osteonecrosis or femoral neck fracture; who gave consent for x-rays were included in the study. Patients who had previously undergone surgery to the same hip (including osteotomy), osteoarthrosis secondary to dysplasias, and those with fixed pelvic obliquity were excluded from the study.

There were 35 men (36 hips) and 16 women (16 hips) with a mean age of 51.3 years (±14.2 years) at the time of operation. Most common indication for primary THA was osteoarthritis in 34.6% of the patients. Other pre-op diagnoses included osteonecrosis, ankylosing spondylitis, rheumatoid arthritis, fracture neck of femur – acute, non-union and neglected, primary osteoarthrosis.

All patients were subjected to X-rays of pelvis with both hips – anteroposterior view, and of pelvis including lumbar spine – lateral view. Pre-operative templating were done basically to evaluate for the centre of rotation and restore limb length.

2.1 Operative technique

Anterolateral (Watson-Jones) approach was used for exposure in all cases. In lateral decubitus position, the pelvic position was confirmed on three occasions for consistency i.e., anterior pelvic plane perpendicular to the ground – once before draping, second after acetabular reaming, and thirdly after femoral preparation.

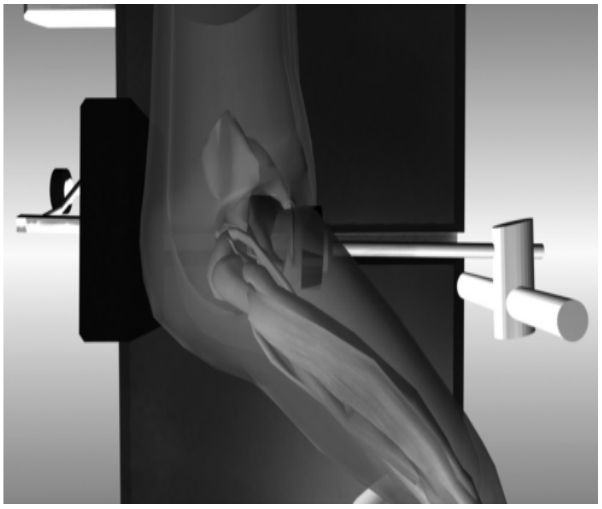

Fig 1: Positioning of pelvis such that APP is perpendicular to ground

After exposure of acetabulum, the appearance of transverse acetabular ligament (TAL) was graded according to the system described by Archbold[5] (Table 1). Once identified, TAL is used as a guide to acetabular reaming – such that the ligament should embrace the final acetabular reamer and thereby, the acetabular component. The inferior edge of the hemispherical reamer should sit just inside the ligament. The inclination of the component is based on the TAL and the residual labrum, by orientating the reamer, and hence the acetabular component, flush with the residual labrum and TAL. Thus, TAL is used as a reference for acetabular depth, version and inclination.

Table 1: The grade of TAL identified on intraoperative exposure of acetabulum

Grade of TAL	Appearance of TAL on exposure[5]	Cases identified in each grade (%)
1	normal-quality TAL visible on exposure of the acetabulum	28 (53.8%)
2	TAL covered by soft tissue, which had to be cleared to expose the ligament	15 (28.8%)
3	TAL covered by osteophytes, which had to be removed to expose the ligament	9 (17.3%)
4	no ligament identified, even after adequate clearance of soft tissue or osteophytes	0 (0%)

For all patients, third generation uncemented press fit prosthesis with primary fixation stability was used. The articulation was metal-on-polyethylene in all cases. The patients were mobilized a day or two after surgery and were discharged when they were mobilizing independently.

Standard post-operative management and follow up was done at 6 weeks and 3 months after surgery for clinical correlation. Radiological evaluation was done in immediate post-operative X-ray. All patients were subjected for pre and post-operative Modified Harris Hip Scoring and documented.

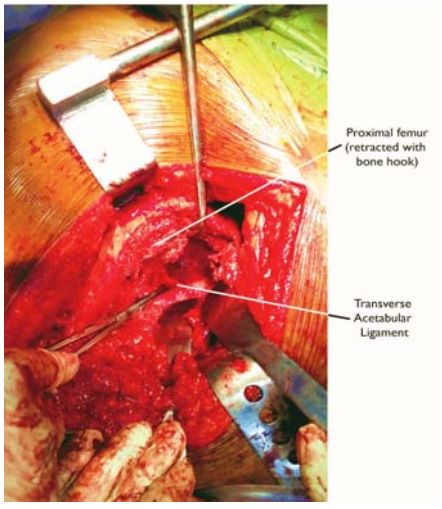

Fig 2: Following extraction of femoral head & neck, acetabulum exposed to identify the TAL

Fig 3: Acetabular reamer placed parallel to TAL and reamed

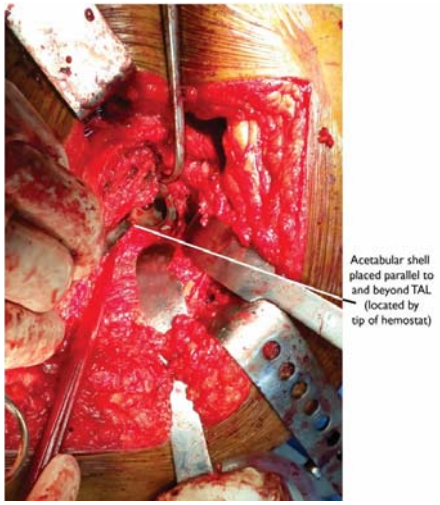

Fig 4: Uncemented acetabular component is impacted in the same direction of the final trial, and adjusted for functional anteversion and abduction angle

2.2 Analysis of cup placement

All were subjected to 2 anteroposterior X-rays - X-ray focusing on pubic symphysis including both hips, and another focusing on the head of the prosthesis. After confirming the symmetry of radiographs, inclination was measured from the first radiograph with interteardrop line as reference line. Anteversion was measured using Lewinnek's method by reconstructing the ellipse made by the circular base of acetabular cup using edge detection software – PolyWare, by Draftware Inc. The PolyWare programme determines anteversion of the component via edge detection on the AP radiograph. D1 is the short axis of the ellipse and D2 is the long axis. The ratio is tabulated, Version = arc sine (D1/D2).

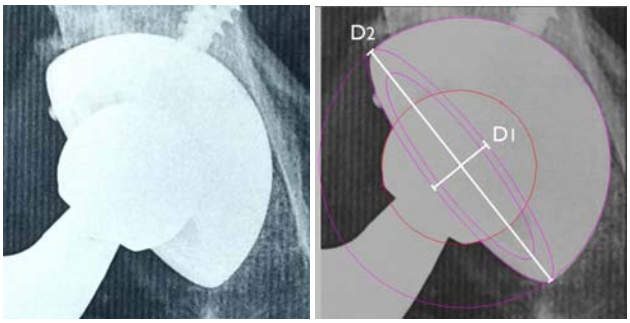

Fig 5: Post-op X-ray – Radiological planar anteversion using edge detection software.

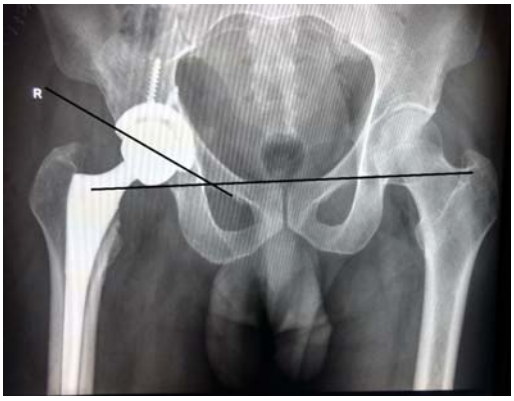

Fig 6: Inclination measured using inter-teardrop reference line and long axis of ellipse formed by opening face of acetabular component

3. Results

TAL was identifiable in all cases. 28 hips had Grade I TAL, 15 hips were grade 2, grade 3 seen in 9 hips. In cases where TAL was covered by osteophytes, small diameter acetabular reamers were used to remove them to expose TAL. There was difficulty in achieving expected anteversion and abduction in cases who were morbidly obese, due to soft tissue thickness. Additional secondary fixation devices were used some patients.

Mean acetabular cup anteversion was 19.84°±3.81°, with 82.6% (n=43) cups within Lewinnek's safe zone. Mean acetabular inclination was 43.65°±3.2°, with 76.9% (n=40) cups within the safe zone.

Intra-operatively we had no complications and achieved stable hips with good ROM. The limb length discrepancy ranged from 0 to 1.6 cm. None of the patients had subjective symptoms because of this. The mean flexion at hip was 110º (100º to 122º). Mean abduction was 33º (26º to 40º). Mean adduction was 19º (13º to 24º). Internal rotation had mean of 16º (13º to 23º). Mean external rotation was 24º (18º to 27º). The mean post-operative stay was 10.7 days.

4. Discussion

Ideal placement of the acetabular component remains elusive both in terms of defining it and in achieving a target. Lewinnek *et al.* proposed a 'safe zone' for cup positioning that reduced the dislocation rate by fourfold[6]. Based on their study, the target for radiographic abduction and anteversion angles are 40° (range: 30–50°) and 15° (range: 5–25°), respectively. Although the definitions and therefore measurements of radiographic and operative angles are slightly different, anterior pelvic plane is used for both measurements.

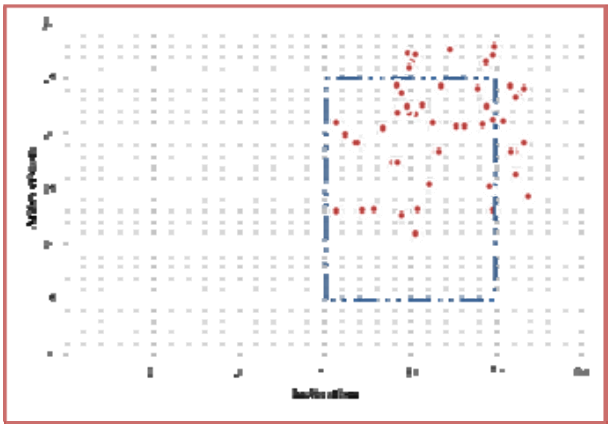

Fig 7: The scattered distribution of inclination and anteversion of all cases in the study

Recent studies support the use of transverse acetabular ligament in determining the anteversion of the acetabular component. In the normal hip the TAL and labrum extend beyond the equator of the femoral head, and therefore, if the definitive acetabular component is placed such that it is cradled by and just deep to the plane of the TAL and the labrum, the center of the hip should be restored.

Literature studying the use of TAL as a guide in acetabular component placement has mostly produced favourable outcomes in their cases, except for few studies that do not validate the use of TAL to cause significant improvements.

With respect to anteversion, there are two major advantages of using the TAL. Firstly, it is patient specific. Placement of

the acetabular cup based on an anatomical landmark, whose anatomy varies and is unique with each patient allows for cup placement in patient specific anteversion and inclination. Thus, the technique transcends the definition of safe zone for AC placement and achieves patient specific versions of AC. Secondly, the TAL is independent of the position of the patient. Most hip arthroplasties are done in lateral decubitus position – with the intention to achieve the APP perpendicular to the plane of the table. However, the pelvis is seldom held in the perfect position. Pelvis is often flexed and adducted. It has been shown that the variation of anterior and posterior pelvic tilt between individuals can be up to 30°. Cup placement by various techniques including freehand placement, using angle guides or jigs, are easily influenced by the pelvic malposition. TAL being an anatomical landmark, is immune to patient position and allows for consistent and reproducible cup placement within the safe zone.

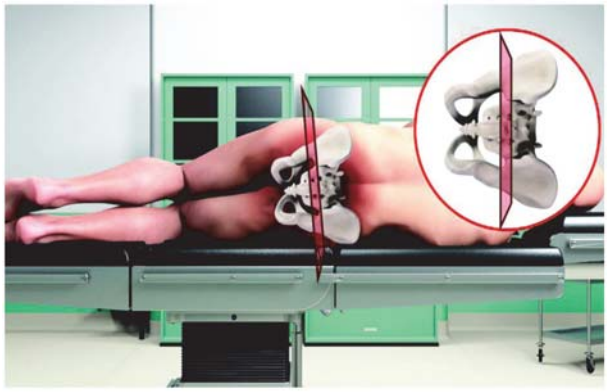

Fig 8: Despite precautions, pelvis is often adducted in the lateral decubitus position

Three factors determine the post-operative radiological inclination (RI):

- Operative inclination (OI). This is the angle between the acetabular axis and the sagittal plane of the pelvis. From the surgeon's view point, apparent operative inclination (AOI) is the angle between the acetabular axis and the floor of the operating theatre. We refer to this as "apparent" because, despite best intentions, the sagittal plane of the pelvis and the floor of theatre are not always parallel.
- Operative anteversion: This increases RI.
- Position of the pelvis. Lateral decubitus remains the most common position for THA and in theory, during surgery, the pelvis is square with respect to the operating theatre - the APP is parallel to the side wall of the theatre

Archbold *et al* in 2006 [5] introduced the use of the TAL as a patient specific reference point in determining the correct AC anteversion. With a large sample size (1000 cases), the TAL was easily identified in most cases (997 cases) and a very low rate of dislocation (0.6%) was seen. Importantly, limitations of this technique were recognized i.e. severe dysplasia or following pelvic trauma – both of which have been excluded in this study. They identified Grade 1 TAL in 490 cases, Grade 2 in 351 cases, 156 cases had grade 3 TAL while TAL could not be identified in 3 cases (Grade 4). In our study, TAL was identified in all cases. 14 cases were grade 1, 7 cases grade 2, and 5 cases had grade 3, which is in agreement with the incidence of TAL in their study.

One of the few studies which was critical about the use of TAL was by Epstein *et al*, 2011 [7]**;** comparing the use of the TAL for positioning the AC with conventional freehand methods. They compared anteversion and abduction angles using TAL and freehand technique. They identified TAL in only 47% of 64 hips in a prospective series of patients who underwent primary THA. They concluded that the TAL was not regularly identifiable and that its use as a reference aid for correct AC anteversion was no more accurate than a conventional freehand technique. However the study includes significant methodological flaws – the two surgeons had contrasting experiences in their ability to identify the TAL; one surgeon had far less outliers than the other; and the use of Woo and Morrey technique of measuring anteversion which has been proven to have poor reliability in measurement of radiological anteversion. Therefore its conclusions must be taken with caution.

The authors identified TAL in all cases. However, owing to low volume of cases, larger case series is required to statistically prove for the interobserver validity of this technique.

5. Conclusion

Using the TAL as the intra-operative landmark for anteversion is simple and reproducible for optimal cup implantation, and enables the cup to closely restore the individual anatomy of the hip joint – within the safe zone – hence precludes the complications that follow malpositioning of acetabular component.

With respect to anteversion, TAL is patient-specific and is independent of the paitent's position on table. However, with respect to inclination, TAL cannot be used alone as a reliable guide, as it is influenced by operative anteversion, operative inclination and patient position.

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