



## The role of the transverse acetabular ligament in total hip arthroplasty

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We performed a systematic literature review to evaluate the role of the transverse acetabular ligament as a reference aid when determining acetabular component anteversion in total hip arthroplasty.

We conducted a literature search in the MEDLINE, EMBASE and Pubmed databases using the key words 'transverse acetabular ligament' and 'arthroplasty'. Four studies published between 2006 and 2011, reporting on 1,217 procedures met our inclusion and exclusion criteria and were eligible for final evaluation. Outcome measures were the ability to identify the transverse acetabular ligament, anteversion of the acetabular component and dislocation rate.

The methodological quality of the studies was variable and they were not homogenous enough for meta-analysis. We found that there was good evidence for the use of the transverse acetabular ligament in terms of accuracy of acetabular component anteversion. However, the ligament could not be routinely identified intra-operatively and other methods of determining the correct anteversion are recommended in this situation. The dislocation rate using this technique was low but it must be stressed that the cause of post-operative dislocation in total hip arthroplasty is multi-factorial and cannot solely be attributed to acetabular component orientation.

**Keywords :** transverse acetabular ligament ; hip arthroplasty.

### INTRODUCTION

The UK National Joint Registry (6) reported that 68,907 primary THAs were performed in 2010. In the same year, a total of 7,852 hip revision proce-

dures were performed for aseptic loosening (50%), followed by pain (27%) and dislocation (17%). Dislocations occur in 0.3% to 10% of cases after primary total hip replacements and in up to 28% after revision hip replacement (13). They significantly increase morbidity and the cost of health care due to the need for revision surgery. Litigation and malpractice claims are often substantial following THA with dislocation listed as being a common cause along with nerve injury, limb length discrepancy, infection and vascular injury (15). The cause of dislocation after THA is multifactorial and surgical factors include experience, approach and component design.

One of the variables that can be controlled by the surgeon is the orientation of the acetabular component (AC). In a case series of 300 patients published in 1978, Lewinnek recommended a 'safe-zone' of  $40 \pm 10$  degrees of abduction and  $15 \pm 10$  degrees of anteversion (8). The dislocation rate increased from 1.5% to 6.1% if these values were exceeded. This concept of a 'safe zone' is commonly used when

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performing THA as incorrect positioning also leads to impingement and increased wear. In 2006, Archbold *et al* (1) introduced a popular technique in which the plane between the transverse acetabular ligament (TAL) and the acetabular labrum was used to determine the correct anteversion of the AC. They concluded that the use of this patient specific landmark reduced their dislocation rate. The normal function of the TAL is to act as a tension band between the posteroinferior and anteroinferior aspects of the acetabulum during loading of the hip joint (9).

This systematic literature review was performed primarily to determine whether the TAL could be identified intra operatively in patients undergoing THA and to establish whether its use as a guide for AC orientation resulted in AC anteversion within the “safe zone” described by Lewinnek. As a secondary outcome measure, post-operative dislocation rate was investigated.

## MATERIALS AND METHODS

A comprehensive literature search was performed in July 2012 through MEDLINE® using OVID from 1946 to 2012. The search terms and results are presented (Table I).

A review of abstracts was then performed and studies were selected based on the following inclusion criteria :

- Total hip arthroplasty performed
- TAL used to determine anteversion of the AC
- and/or measurement of anteversion
- and/or dislocation rate reported

Exclusion criteria included papers that were review articles and those that were duplicated in the results of the search. The following three studies were found to be appropriate for review.

- “The transverse acetabular ligament : an aid to orientation of the acetabular component during primary total hip replacement : a preliminary study of 1000 cases investigating post-operative stability” by Archbold HAP *et al* (2006) (1)
- “Acetabular component positioning using the transverse acetabular ligament : can you find it and does it help ?” by Epstein NJ *et al* (2011) (5)
- “The role of the transverse acetabular ligament for acetabular component orientation in total hip replacement” by Kalteis T *et al* (2011) (7)

Table I. — Results of MEDLINE® search

Search	Search Term	Result
1	transverse acetabular ligament.mp.	27
2	arthroplasty.mp. or Arthroplasty/	40540
3	1 and 2	9

A further search using the same terms was performed using EMBASE® from 1947 to 2012 and Pubmed® search engines. The EMBASE® search revealed no further studies but the Pubmed® search revealed one more study suitable for analysis.

- Anteversion of the acetabular component aligned with the transverse acetabular ligament in total hip arthroplasty by Miyoshi H *et al* (2011) (9)

A search for the terms ‘transverse acetabular ligament’ and ‘arthroplasty’ was also performed on the Cochrane Database of Systematic Reviews® but this revealed no further studies. References included in each of the selected papers were also analysed but no further studies were found. This literature search was performed independently by each of the authors and any disagreements were settled through discussion.

A total of four studies were eligible. A critical appraisal of these studies is presented in chronological order of publication. Due to the heterogeneity of methods used for measuring anteversion angles, surgical approaches, patient positioning and implant designs we were unable to pool the data for meta-analysis.

## CRITICAL APPRAISAL OF STUDIES

### Archbold *et al*, 2006

In this case series of 1000 THAs the authors presented their technique of using the plane between the TAL and the acetabular labrum in order to determine the correct anteversion of the AC. The TAL was identified in 99.7% of cases (997/1000) and dislocation rate at a minimum follow up of 8 months (range : 8-41 months) was 0.6% (6/1000). In the three cases in which the TAL was not identified, the authors felt that it may have been inadvertently

destroyed during dissection. Analysis of AC orientation was not performed.

All THAs were performed by the same senior surgeon and a large number of cases were presented. A detailed and reproducible technique was provided. Importantly, limitations of this technique were recognised i.e. severe dysplasia or following pelvic trauma. Although the same posterolateral surgical approach was used in all cases, there were some differences in surgical technique: 400 patients underwent a minimally invasive approach whereas the others underwent a more conventional open approach. Bearing surfaces were also different amongst the patients and were chosen based on age. Also, whereas a neutral acetabular liner was used in 973 cases, 27 hips received an acetabular liner with a 10° lip. These individual factors could have independently affected the outcome measures. However, in clinical practice, it would be difficult to eliminate these entirely. No details are provided of when and how each of the six posterior dislocations occurred.

This paper introduced the use of the TAL as a patient specific reference point in determining the correct AC anteversion. With a large sample size, the TAL was easily identified in most cases and a very low rate of dislocation was seen. There was no post-operative measurement of AC anteversion. The authors did, however, present an easily reproducible and valid technique which is in widespread use today.

### **Epstein *et al*, 2011**

This has been the only study to date comparing the use of the TAL for positioning the AC with conventional freehand methods. In 64 THA procedures performed by two senior surgeons through a posterolateral approach, only 46.8% (30/64) of the hips had an identifiable TAL. In the 34 hips in which the TAL was not identified, free hand positioning of the AC was performed in order to try and obtain 45° of abduction and 20° of anteversion. These formed the control group. Post-operative radiographs were used to calculate the abduction and anteversion angles. Components outside the 'safe zones' suggested by Lewinnek were labelled as outliers. These

measurements were taken by a blinded and independent assessor thereby reducing the risk of detection bias. Results showed that there was no significant difference between the number of outliers in terms of abduction or anteversion. The authors 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, there was a trend towards a more accurate anteversion angle in the experimental group (mean 23.6° versus mean 29.5° for the control group,  $p = 0.0586$ ) suggesting that use of the TAL may be valid. In the three month follow-up period, no dislocations were seen in either group.

There were a number of limitations to this study. The two surgeons had different experiences in their ability to identify the TAL. One was far more successful than the other in this respect (63% versus 32%,  $p = 0.01$ ). The same surgeon also had significantly fewer anteversion outliers than the other (37% versus 63%,  $p = 0.042$ ). They used the method proposed by Woo and Morrey (17) which defines anteversion as the angle formed by a line drawn tangential to the face of the acetabulum and a line perpendicular to the horizontal plane. This only provides an estimate and does not take into consideration the variability in patient positioning whilst performing radiographs. A power study was not performed and there was no randomisation process in allocating patients to treatment groups.

Despite being the only comparative study, significant methodological flaws exist. Therefore, its conclusions must be taken with caution. Of particular importance is that in the group where the TAL was not used for referencing, the mean level of anteversion of the AC (29.5° +/- 13.6) was actually outside Lewinnek's 'safe zone'. The mean level of anteversion in the group that used the TAL technique (23.6 +/- 9.9) was more accurate, implying that actually the TAL may provide a useful reference point.

### **Kalteis *et al*, 2011**

This study was performed in order to assess intra- and interobserver reliability amongst surgeons in defining the plane between the TAL and posterior

labrum, to assess the reliability of using this plane and to assess whether this technique improves post-operative range of motion. Thirty-nine THAs were performed jointly by two senior consultants using computer navigation software and a referenced trial AC. In all cases the TAL was identifiable. The two surgeons each performed the registration process for the AC three times and the abduction and anteversion angles were recorded. They were blinded from the results by having the computer screen turned away from them. The mean abduction and anteversion angles were  $41^\circ$  and  $18^\circ$ , respectively. Thirty-four out of the 39 hips in the study lay within Lewinnek's 'safe zone'. There was moderate intra- and inter-observer reliability with respect to registration of the plane defined by the TAL and posterior labrum. A virtual assessment of post-operative range of motion and impingement was performed using software interpretation of 3D models. In each of 24 hips (15 hips did not have sufficient quality or quantity of anatomical landmarks for accurate 3D modelling), the range of motion and impingement was calculated for two different orientations of the acetabular component. One of these was the position according to the plane defined by the TAL and posterior labrum and the other was software generated orientation of the AC at  $45^\circ$  abduction and  $15^\circ$  anteversion. The results showed no difference in either the range of motion or impingement in the TAL referenced group.

All patients were operated on in a lateral position using a minimally invasive anterior approach by the same two senior surgeons. The same implant and computer navigation system was used for all patients. Also, in order to accurately compare the orientation of the TAL posterior labrum plane with Lewinnek's 'safe zone', values were converted to radiological equivalents through use of the system proposed by Murray (11). Although this study recommends using the TAL as a reference aid, there are a few important limitations. One must question the accuracy of using computer generated 3D models to predict virtual range of motion rather than clinical assessment. Also, the dislocation rate post-operatively was not measured. Despite having only a relatively small sample size, results showed that use of the TAL can be beneficial in AC orientation.

### **Myoshi *et al*, 2011**

This was a retrospective case series investigating 114 consecutive THAs. In 81.6% (93/114) of these, the TAL was identified and an attempt was made to use it for referencing the AC. However, after the authors reviewed the operation records, only 50.5% (47/93) of these were deemed suitable to be included in the study as the AC was positioned unparallel to the TAL either intentionally due to pelvic sagittal tilt (22 cases) or unintentionally (24 cases). CT based measurements revealed a mean anteversion angle of  $21.2^\circ$  with 42 out of 47 hips being within Lewinnek's safe zone. In a subset analysis, there was a comparison between dysplastic and non-dysplastic hips in terms and no difference in mean anteversion was seen. Follow up for CT was for a mean of 9 months (range, 3 weeks to 33 months) and measurements were taken at a mean of 17 months. Three cases of anterior dislocation occurred, all within the first month but these were excluded from CT measuring.

The same two senior surgeons performed all the THAs using the same implants, posterolateral approach and lateral patient position reducing the risk of error posed by confounding variables. The use of CT to measure anteversion is considered a more accurate method than using radiographs. However, there is a reported standard deviation of inter-observer error of  $2.9^\circ$  using CT (12). A single observer took all the measurements three times at two week intervals to reduce both intra and inter-observer variance. However, this observer was also an investigator and was not independent. Statistical analysis was performed but there was no evidence of a power calculation. Also, there was no ethical approval sought despite many patients having clinically unnecessary post-operative CT scans.

A major criticism of this study is the way in which patients were excluded from CT measurements: 24 cases were excluded due to technical error in positioning the acetabular component parallel to the TAL despite the intention to do so. This has led to significant systematic error as this clinically relevant subset has been excluded. It is likely that in clinical practice this error may occur and perhaps, an intention-to-treat principle should have been fol-

lowed. Three post-operative dislocations occurred but this was not further analysed so conclusions regarding dislocation cannot be drawn.

This study highlighted numerous technical issues with use of the TAL as a referencing aid. Firstly, they suggested that identification of the TAL can be difficult in patients with advanced degenerative disease. Secondly, they discovered that during the final seating of the press-fit AC the position could change respective to the TAL. Finally, whilst they showed that in almost 90% of cases positioning the AC parallel to the TAL gave an anteversion angle within Lewinnek's 'safe zone', they urged caution with dysplastic hips with increased sagittal tilt.

## RESULTS

### Anteversion and Lewinnek's 'safe zone'

Archbold *et al* recommended a technique in which the acetabular component is aligned parallel to the plane between the TAL and the acetabular labrum and their results showed a very low rate of dislocation. However, in this study no assessment of post-operative acetabular component orientation was made. A subsequent magnetic resonance imaging study of osteoarthritic hips by the same group found the TAL plane to lie within 5.3° to 36.1° of anteversion in the sagittal plane and highlighted the need for a patient specific reference point. Whilst Epstein *et al* concluded that acetabular position was not improved using the TAL for referencing the AC, there was a clear trend towards more accurate placement within the 'safe zone' and statistical significance may have been shown if a larger sample size was chosen. In subsequent studies by Kalteis *et al* and Myoshi *et al*, accurate anteversion angles with this technique were also proven. As demonstrated by this review, this technique has shown to be consistently accurate in determining the correct amount of anteversion as suggested by Lewinnek.

### Identification of the TAL

A major criticism of this technique seems to be that the TAL cannot be consistently identified intra-

operatively. Archbold *et al* originally claimed that it was seen in 99.7% of cases (997/1000) and Kalteis *et al* were able to identify it in all of their 39 THAs. Myoshi *et al* were able to identify it in 81.6% of cases (93/114). However, Epstein *et al* realised this in only 47% of cases (30/64). This variance may be due to reasons such as differences in experience in using this technique and the stage of the disease process. The more advanced the disease, the more osteophytes are likely to be present on the rim of the acetabulum. It may be that in clearing these osteophytes the TAL may be inadvertently removed. The TAL itself may also be atrophied and difficult to differentiate from surrounding soft tissue.

### Dislocation rate

Few studies have attempted to correlate the incidence of dislocation with use of the TAL as a reference aid in AC positioning. Whilst Archbold *et al* revealed an extremely low dislocation rate of 0.6%, no other study has attempted to formally reassess this. Epstein *et al* noted no dislocations in their short follow-up period and Miyoshi *et al* had three dislocations in the first post-operative month but in only one was the TAL technique used. This was not further analysed as part of the study. An explanation for the lack of reporting of dislocation following the use of this technique is that dislocation following THA is multifactorial and cannot solely be attributed to incorrect AC orientation.

## DISCUSSION

Malpositioning of the AC during THA may lead to numerous complications including dislocation, increased wear and impingement. Improved orientation can minimise the risk of these complications and result in a better outcome for the patient. Current evidence suggests that use of the TAL for referencing the orientation of the AC provides accurate anteversion in terms of Lewinnek's 'safe zone'. Robust randomised clinical trials would need to be performed to confirm that this method is more accurate than any other. It is important to note that intra-operative visualisation of the TAL can sometimes be difficult and in this situation, other tech-

niques of determining correct AC orientation must be employed.

A limitation of this review was the use of Lewinnek's 'safe zone' to define accurate anteversion. This was based on a dated study reviewing only nine dislocations where measurements of AC anteversion were made using unvalidated radiographic methods. The concept of an ideal AC orientation remains controversial and despite this, other investigators (4) have produced similar results to Lewinnek and his concept is well established and accepted by many – but not all – arthroplasty surgeons.

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