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Basic Science

The Transverse Acetabular Ligament as an Intraoperative Guide to Cup Abduction

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ABSTRACT

Background: The success of a total hip arthroplasty relies on optimal acetabular cup placement to ensure mating of the femoral head and acetabular cup throughout all positions of the hip joint. Poor cup placement is associated with dislocation, impingement, microseparation, component loosening, and accelerated wear due to rim loading. This study examined a novel method of using the transverse acetabular ligament (TAL) to guide cup inclination during primary total hip arthroplasty.
Methods: A descriptive study using 16 hips from 9 cadavers. A computer navigation system measured inclination and version of the acetabular component in 3 positions with the lower edge of cup: (1) flush with, (2) 5 mm proximal to, and (3) 5 mm distal to free border of the TAL.
Results: The median inclination angles were 44° in position (1), 30° in position (2), and 64° in position (3). The median anteversion angle for all positions was 19°.
Conclusion: Cup inclination was acceptable when the lower edge of the cup was flush or within 5 mm proximal to the TAL.

Introduction

The success of a total hip arthroplasty relies on optimal acetabular cup placement to ensure mating of the femoral head and acetabular cup throughout all positions of the hip joint [1,2]. Poor cup placement is associated with dislocation, impingement, microseparation, component loosening, and accelerated wear due to rim loading [3].

In a series of 300 total hip arthroplasties by Lewinnek et al in 1978, the now widely quoted “safe zones” for acetabular cup placement were defined as an anteversion angle of 5°-25° and an inclination (abduction) angle of 30°-50°. When placed within these parameters, the dislocation rate was only 1.5% compared with 6.1% when cups were placed outside of these safe zones [4].

Several techniques exist to aid the surgeon intraoperatively with optimal cup positioning, including mechanical alignment guides, but only moderate accuracy has been achieved with these methods [5-7]. Inaccuracy with the conventional cup placement techniques can be due to several factors, for example, surgeon estimation error [8], variation in patient anatomy [9], and intraoperative change in pelvic orientation [7,10,11]. Positioning on the operating table, dislocation of the native hip, and the use of retractors can all cause intraoperative pelvic movement, which changes pelvic orientation [12]. This can cause misjudgment of acetabular component orientation, whether done by freehand or with mechanical guides. In the lateral decubitus position, there is a tendency for the hemipelvis on the affected side to adduct during total hip arthroplasty [13].

Computer-assisted navigation systems (CAN systems) have recently been introduced to improve the accuracy of acetabular component placement. Here, the cup orientation is measured relative to the anterior pelvic plane (APP), as initially described by McKibbin [14] in 1970, and this technique has been shown to be more accurate than conventional methods [15,16]. Accuracy rates

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of 1.8° ± 1.2° for inclination and 2.0° ± 2.0° for anteversion have been recorded [17]. Using different makes of CAN systems has no significant effect on the accuracy [18-20].

The accuracy of CAN systems depends on accurate registration of the reference points of the APP, that is, the bilateral anterior superior iliac spinae and pubic tubercles. Determination of these reference points is influenced by obesity and osteoporosis, resulting in inaccurate registration of the APP in these conditions [20-22].

CAN systems are expensive and can be cumbersome to set up. Cheaper and more user-friendly methods are required. Intraoperative landmarks are patient-specific, reproducible, and independent of patient position and have been investigated as an intraoperative orientation guide. Of these landmarks [23], the position of the cup in relationship to the transverse acetabular ligament (TAL) appears most promising [8,9,12,23-26].

The TAL bridges the inferior acetabular notch, and although it is submitted to tension during loading of the acetabulum [27], its function is not fully understood [28]. Archbold et al reported 1000 consecutive primary total hip arthroplasties, during which the TAL was used to determine anteversion, while inclination was determined by the remainder of the posterior labrum. The authors report a 0.6% dislocation rate at minimum of 8month follow-up. An intraoperative grading system of TAL visibility, now widely known as the Beverland classification of the TAL, was also introduced in this article. In summary, this grading system classifies the TAL into 1 of 4 grades based on its visibility, with grade 1 being a normal TAL that is visible on exposure of the acetabulum. In grades 2 and 3 TAL, the ligament is covered by soft tissue (grade 2) and bone (grade 3), respectively, which has to be removed to visualize the TAL. When no TAL can be identified, even after adequate removal of osteophytes and soft tissue, it is classified as a grade 4 TAL [24].

In a subsequent study by Archbold et al [29], the orientation of the combined TAL and posterior labrum plane, in relation to the APP, was measured with magnetic resonance imaging arthrography. Both inclination and anteversion angles were within Lewinnek's safe zones.

Other studies, using CAN [30] and intraoperative alignment of the cup with the superficial edge of the TAL [25], resulted in consistent cup placement within Lewinnek's safe zone for anteversion; inclination was not reported on.

In contrast, Epstein et al [26] used the TAL as an intraoperative guide to cup positioning with results no better than conventional freehand cup positioning.

The focus of research on the TAL as an operative guide has largely been done on anteversion and not inclination. Some authors have described using the combined TAL and posterior labrum plane to guide cup inclination [29]; however, to our knowledge, there is no quantitative study describing the changing inclination of the cup in relation to the distance from the TAL. We therefore examined whether the distance from the TAL could be used as a reliable intraoperative guide for cup inclination.

Materials and Methods

Approval to conduct the study was obtained from the institutional ethics committee. The study design was prospective and descriptive.

Eighteen hips from 9 formalin-preserved cadaveric specimens were originally included. Exclusion criteria were significant abnormalities of the hips (eg, acetabular dysplasia or previous hip arthroplasty), as identified by a standard anteroposterior radiograph of each cadaver. This resulted in the exclusion of 2 hips from different cadavers; therefore, the study sample was 16 hips from 9 cadavers. The cadaver mean age at death was 64 years (range, 53-88 years).

With the cadaver in the floppy lateral position, the APP was recorded by registration of both anterior superior iliac spinae and pubic tubercles using a Brainlab computer navigation system.

The posterior approach to the hip as described by Moore was used, with a 15cm posteriorly curved skin incision centered over the posterior aspect of the greater trochanter. The gluteus maximus was split in line with its fibers to expose the short external rotators which were secured with stay sutures, divided 0.5 cm posterior to their femoral insertion, and then, retracted posteriorly en masse taking care to protect the sciatic nerve. A capsulotomy was performed, and the hip was dislocated posteriorly. To allow proper exposure of the entire acetabulum, the labrum and the remains of the ligamentum teres were excised. The TAL was promptly visualized in all hips.

Concentric reaming of the acetabulum was done parallel to the TAL, ensuring that the final reamer assumed a position where its inferior edge was flush with the free border of the TAL. A trial cup was then introduced into the acetabulum, and orientation of this cup was measured with the computer navigation system (Fig. 1).

First, the anteversion of the acetabulum was recorded with the inferior edge of the cup parallel to the TAL. This degree of anteversion was maintained throughout the different positions of abduction. Anteversion was thus standardized to isolate the effect of distance from the TAL on abduction angle. Inclination was then recorded with the inferior rim of the cup in each of the following 3 positions (Fig. 2):

(1) Flush with the TAL (0 mm);
(2) Displaced 5 mm proximal to the free border of the TAL (−5 mm);

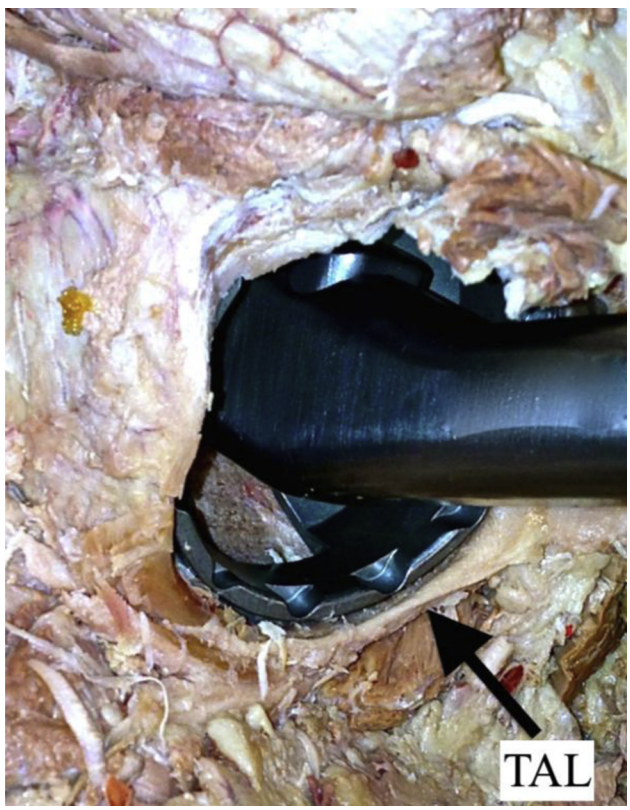

Fig. 1. The hemispherical trail cup is cradled by the TAL. TAL, transverse acetabular ligament.