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## **Patient positioning and cup orientation during total hip arthroplasty:**

### **Assessment of current UK practice**

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## **Abstract**

### Introduction

Acetabular cup orientation during total hip arthroplasty (THA) remains a challenge. This is influenced by patient positioning during surgery and the method used to orientate the acetabular cup. The aim of this study was to assess current UK practice for patient positioning and cup orientation, particularly with respect to patient supports and techniques used to achieve target version and inclination.

### Method

A literature review and pilot study were initially conducted to develop the questionnaire, which was completed by British Hip Society members (n=183). As the majority of THA surgical procedures within the UK are performed with the patient in *lateral decubitus*, orthopaedic surgeons who operated with the patient in the supine position were excluded (n = 18); a further 6% were incomplete and also excluded (n=11).

### Results

Of those who operated in *lateral decubitus*, 76.6% (n=118/154) used the posterior approach. Only 31% (n=47/154) considered their supports to be completely rigid. More than 35% (n=55/154) were unhappy with the supports that they presently use. The most common methods for controlling operative inclination and version were a mechanical alignment guide (MAG; n=78/154; 50.6%]) and the transverse acetabular ligament (TAL; n=82/154; 53.2%]); 31.2% (48/154) used a freehand technique to control operative inclination.

## Conclusion

Limited studies have been conducted whereby patient supports have been analysed and key design principles outlined. With 35.7% of the orthopaedic surgeons surveyed having issues with their current supports, a greater awareness of essential characteristics for patient supports is required.

## Key Words

Total hip arthroplasty; patient positioning; acetabular cup orientation; supports

## Introduction

There are several approaches available to an orthopaedic surgeon for controlling intra-operative acetabular orientation.<sup>1</sup> With respect to operative inclination, a mechanical alignment guide (MAG) or freehand approach may be used in reference to the surgical theatre floor, with the latter acting as an “external” landmark. The MAG has been shown to reduce acetabular positioning errors relative to a fixed target for intra-operative inclination when compared to a freehand technique.<sup>2-5</sup> However, both techniques are potentially compromised by using the external theatre floor. For the external theatre floor to be a viable landmark for controlling operative inclination, the internal pelvic sagittal plane has to be parallel to the external theatre floor. This ensures that the two anterior superior iliac spines are vertical with respect to each other. Adduction (Figure 1a) and or internal rotation (Figure 1b) of the upper hemipelvis results in the apparent operative inclination (i.e. angle between the introducer and theatre floor) being less than the true operative inclination (i.e. angle between the introducer and the sagittal plane). Consequently, a higher radiographic inclination will also be observed.

For operative version, a MAG or freehand approach may be used in reference to the theatre table longitudinal axis, with the latter acting as an “external” landmark. In this instance, the use of the external theatre table longitudinal axis is compromised if the angle between it and the internal anterior pelvic plane (APP) is unknown. The use of internal patient-specific landmarks, such as the transverse acetabular ligament (TAL),<sup>6</sup> can compensate for intra-operative variation in pelvic tilt (i.e. rotation about the pelvic transverse axis). TAL has been associated with a reduced risk of dislocation.<sup>6</sup>

With respect to patient positioning, it is clearly important to have an understanding of the intra-operative position of the pelvis relative to the external theatre when implanting

the acetabular component. Milone et al<sup>7</sup> obtained absolute acetabular cup placement errors of up to 20° when using external landmarks. This was particularly important for operative version, with 22% (n = 22/100) of their cases being placed more than 10° away from their intended target. Milone et al<sup>7</sup> concluded that patient positioning could not be relied on when orientating the acetabular cup. Grammatopoulos et al<sup>8</sup> have illustrated that pelvic position deviates from its intended position during both pre-operative patient positioning and intra-operatively. Subsequent intra-operative movement may result from inadequate fixation and/or retraction forces during THA.<sup>9</sup> Grammatopoulos et al<sup>8</sup> also observed that the choice of patient support could be used to reduce the extent of pelvic movement. Although different supports were used, this finding was maintained by Iwakiri et al.<sup>10</sup>

Traditionally with respect to acetabular cup orientation, orthopaedic surgeons have targeted the Lewinnek safe zone,<sup>11</sup> which recommends 40 ± 10° of radiographic inclination and 15 ± 10° of radiographic version (Figure 2). However, this recommendation was based on observations from a study of only nine dislocations. More recent studies have shown that up to 60% (n = 76/127) of dislocations can be within the Lewinnek safe zone.<sup>12-14</sup> Although alternate safe zones have been proposed, a general consensus from the orthopaedic surgical community has not been reached.<sup>13,15</sup> Nevertheless, several clinical studies have reported that mal-positioning of the acetabular cup has been associated with increased risk of dislocation<sup>11,12,16-21</sup> and a greater rate of wear.<sup>22-30</sup>

A one-size-fits-all acetabular cup version target may not be applicable due to variations in the native orientation of the acetabulum between patients. Archbold et al<sup>31</sup> reported that the native variation in TAL-*labrum* version relative to the anterior



pelvic plane was over 30°. Goudie et al found that 75% of their cohort (n = 49/65) had a native acetabular orientation outside the Lewinnek safe zone.<sup>32</sup> Additionally, there was a significant difference in the extent of acetabular radiographic version between male and female cohorts. These conclusions are in agreement with the findings by Murtha et al.<sup>33</sup>

The aim of this research was to establish current UK surgical practice with respect to pre-operative patient positioning in *lateral decubitus*, as the majority of THA surgical procedures within the UK are performed with the patient in this position,<sup>34</sup> and secondly to determine the techniques used to achieve target version and inclination. The research aim was tested by way of a questionnaire, which was completed by members of the British Hip Society within the period between April and June of 2014.

## Method

A review of the commercially available apparatus for intra-operative pelvic positioning in *lateral decubitus* was conducted by assessing commercially available technology and reviewing intellectual property applications using the Google Patents database. A separate literature review was performed to learn the most commonly used surgical methods for determining intra-operative acetabular cup orientation, namely inclination and version, using PubMed and the UK National Joint Registry (NJR).<sup>34</sup> Key search words included: pelvis, pelvic, orientation, position, patient positioning, *hip replacement*, *hip arthroplasty*, *supports*, *acetabular*, and *acetabulum*. Information collated from this literature review was used to support the development of an initial sample questionnaire for establishing current UK surgical practice and to comprehend how current technology meets user needs.

From the NJR,<sup>34</sup> it was apparent that the greatest majority (91%) of THA procedures conducted within the UK were performed with the patient in the *lateral decubitus* position. Given that our interest focused on surgical supports, it was decided to exclude orthopaedic surgeons who operated with the patient in the supine position from the study.

The initial questionnaire facilitated technical feedback from a sample cohort of the orthopaedic community (n = 21), which was used to refine the questions for the final questionnaire. This initial questionnaire was completed by orthopaedic surgeons from five different orthopaedic centres from across the UK.

An extended questionnaire<sup>35</sup> was developed using SurveyMonkey® (SurveyMonkey Inc., USA), which facilitated easier access to the survey, more reliable data collection

and the efficient use of pathway logic. The extended questionnaire was reviewed by a statistician to eliminate bias and to ensure the practicality of the questionnaire.

With the permission and assistance of the British Hip Society, a web link to the questionnaire was emailed to all its members. Descriptive statistics (frequency plots, mean, standard deviation, and mode) were calculated using Microsoft Excel (Microsoft Corporation, USA).

## **Results**

A total of 183 members from the British Hip Society responded to the extended questionnaire via SurveyMonkey®. Eleven (6%) surveys were returned incomplete and thus excluded from analysis. A further 18 (9.8%) surveys were excluded because the orthopaedic surgeon operated with the patient in the supine position, which resulted in 154 questionnaires (84%) being considered for analysis.

The maximum number of THA procedures performed by an orthopaedic surgeon per annum was 500 and the minimum performed was 20. The mean number ( $\pm$ SD) of THA procedures performed per annum was 142 ( $\pm$ 85). The most commonly reported period of surgical practice was 15 years or more ( $n = 55/154$ ; 35.7%, Figure 3).

The most popular choice of anterior surgical supports for positioning the patient intra-operatively was a double “goal post” design ( $n = 45/154$ ; 29.2%, Figure 4a). The two posts engage the anterior superior iliac spines and can be moved both horizontally and vertically relative to each other. The second preferred choice was a single post design for engaging the upper anterior superior iliac spine using a universal ball joint ( $n = 33/154$ ; 21.4%). In addition to the popular double anterior superior iliac spine anterior support design, other pelvic supports within the questionnaire also featured the use of two anterior superior iliac spine supports. In total, 44.1% ( $n = 68/154$ ) of the

respondents used anterior supports that engaged both of the anterior superior iliac spines. Of those respondents using two anterior superior iliac spine posts, irrespective of design (n = 68/154; 44.1%), 72.0% (n = 49/68) used two anterior superior iliac spines supports that could be moved both horizontally and vertically relative to each other, while only 23.5% (n = 16/68) used two ASIS supports that could only be moved vertically. With this latter support type, if both ASIS are engaged then the pelvic sagittal plane should be parallel to the theatre floor. The remainder of double anterior superior iliac spine surgical supports considered were either fixed (n = 1/68; 1.4%) or could be moved horizontally (n = 2/68; 2.9%) relative to each other.

With respect to posterior surgical supports, the most common style was a flat faced design (n = 95/154; 61.7%, Figure 4b). When positioning the posterior support, most orthopaedic surgeons aimed to engage the sacrum (n = 81/154; 52.6%). The majority of respondents were directly involved or supervised initial patient positioning within the surgical supports (n = 151/154; 98.0%).

Within the questionnaire, the supports were classified as being rigid if the “supports never give way and do not show signs of movement intra-operatively or at the end of surgery”. In response, only 30.5% of respondents (47/154) stated that their supports (both anterior and posterior) were completely rigid. The majority of respondents (120/154; 77.9%) were unaware of the manufacturer or the trade name of the supports being used during THA.

The most reported issue with respect to surgical prop design was that their placement was limited by gaps in the rails of the surgical tables (n = 44/154). With respect to perceived limitations, 47.4% (n=73/154) reported no issues with their supports. However, respondents noted some negative side-effects that included: skin break

(n=23/154; 14.9%), bruising (n=19/154; 12.3%) and nerve injury (n=13/154; 8.4%). Respondents reported skin break and bruising around the pubis symphysis and anterior superior iliac regions, whilst nerve injury was noted as occurring to the *lateral cutaneous* nerve of the thigh.

The majority of orthopaedic surgeons (n = 121/154; 78.6%) reported that the surgical supports were not radiolucent. However, most of these surgeons (n = 112/154; 72.7%) also stated that they never used intra-operative radiographic imaging. More than a third of the respondents (n = 55/154; 35.7%) would like to change the surgical supports they currently use during THA.

With regard to surgical approach used during THA, 76.6% (118/154) were posterior and 22% lateral (34/154). To control operative inclination, 50.6% (78/154) used a MAG and 31.2% (48/154) used a freehand technique. Through extrapolation, 83.1% (128/154) used the theatre floor as an external landmark (Table 1). The mean target radiographic inclination was  $42.6^{\circ}$  ( $\pm 2.94^{\circ}$ , min =  $30^{\circ}$ , max =  $52^{\circ}$ ) which fits within the Lewinnek safe zone. To control operative version, 52.3% (82/154) used the TAL (Table 1).

## **Discussion**

The aim of this research was to establish current UK surgical practice with respect to preoperative patient positioning in *lateral decubitus*, and secondly the techniques used to achieve target version and inclination. The main outcomes will be discussed below.

With respect to patient positioning and anterior supports, 21.4% of orthopaedic surgeons used a single support placed on the uppermost ASIS. Grammatopoulos et al<sup>8</sup> demonstrated that the use of two anterior superior iliac spine supports reduced

intra-operative pelvic movement when compared to a single anterior superior iliac spine brace arm. They concluded that the use of a single anterior superior iliac spine support combined with a posterior support over the lumbosacral spine tended to force the upper hemi-pelvis to externally rotate. When using the theatre floor as an external landmark, this would result in a reduction in the expected radiographic inclination.<sup>36</sup> Although 44% (n=68/154) of orthopaedic surgeons in the UK used two anterior superior iliac spine supports, only 10.4% (16/154) adopted a support system in which the horizontal bars were maintained at the same length. As with the use of a single anterior superior iliac spine brace arm, for two horizontally adjustable anterior superior iliac spine brace arms, over-extension of one anterior superior iliac spine brace arm relative to the other will induce pelvic rotation about the longitudinal axis. Thus, it would appear logical that the pelvis would ideally be held in neutral rotation by using two anterior superior iliac spine brace arms that are of equal length relative to each other, but can be adjusted vertically to allow for different inter- anterior superior iliac spine distances.<sup>37-38</sup>

The use of two anterior superior iliac spine brace arms that are maintained at the same length does not necessarily ensure that the pelvic sagittal plane is parallel to the theatre floor. Firstly, both anterior superior iliac spines have to be engaged, but that only ensures that they are vertical with respect to each other in the pelvic coronal plane. They may not be vertical within the pelvic transverse plane and, consequently, the pelvis may be adducted or abducted. Adduction appears as a lowering of the operative hip towards the surgical theatre floor (positive), whilst abduction represents the opposite motion (negative). Grammatopoulos et al<sup>8</sup> indicated a mean adduction angle of 4° (2SD ± 12), at patient set up, followed by intra-operative movement ( $\bar{x}$  = 9°). This finding is supported by the current questionnaire, with only 31% (n = 47/154)

considering their supports to be completely rigid and, thus, maintaining a stable pelvic position. Use of the theatre floor as an external landmark in this instance (using a MAG or freehand technique), would result in a radiographic inclination approximately 13° higher than expected.<sup>36</sup> It is expected that this would have a negative effect on outcomes as high radiographic inclination angles contribute to component wear<sup>22-23</sup> and risk of dislocation.<sup>16</sup>

The results of the questionnaire indicated that most orthopaedic surgeons relied on a MAG or the freehand technique to control inclination (n = 126/154; 81.8%). Positioning relative to the TAL was the most common method to control version, albeit with a smaller majority (n = 82/154; 53.2% for TAL vs. n = 62/154; 40.2% for MAG plus the freehand technique). Thus, there are many orthopaedic surgeons that rely on the use of external landmarks for controlling both operative inclination (theatre floor) and version (long axis of the patient or theatre table). For operative inclination, the use of a MAG has been shown to increase the orthopaedic surgeon's ability to achieve their target orientation relative to the theatre floor when compared to using the freehand technique.<sup>2-5</sup> However, as discussed, it is important to ensure that the pelvic sagittal plane is parallel to the theatre floor at the time of acetabular cup insertion by correct patient positioning and by using appropriate patient supports. With regard to version, in agreement with the findings of this study, we feel that using an internal landmark such as the TAL is a more appropriate choice for controlling version. The TAL is a patient specific landmark,<sup>31</sup> independent of pelvic orientation, which has been associated with an increased probability of safe acetabular cup placement.<sup>39-41</sup>

Approximately 78% of the orthopaedic surgeons (n = 120/154) were unaware of the specific brand or manufacturer of the surgical supports that they used during THA. This is possibly because orthopaedic surgeons may not have a principal role in

surgical support selection or procurement. Interestingly, 35.7% (n = 55/154) of the respondents highlighted that they would like to improve the surgical supports they currently use during THA. However, financial constraints within individual orthopaedic centres may be a limiting factor in selection and procurement of preferred surgical supports.

Based on the data from this study, we conclude a large volume of orthopaedic surgeons rely on freehand or MAG techniques, which use external landmarks for controlling operative inclination (n = 126/154; 81.8%) and operative version (n = 62/154; 40.3%). When using external landmarks for guiding the acetabular cup, the intra-operative position of the pelvis relative to these landmarks must be known. For the sagittal plane this may be achieved via suitable patient fixation supports. However, from the orthopaedic perspective, existing supports may lack rigidity (n = 107/154; 69%) and their placement can be limited by the rails in the surgical table (n = 44/154, 28.6%). There are few studies that investigate the impact of surgical support design on intra-operative pelvic position.<sup>7-8,10</sup> Of these studies, the number of designs investigated within each study is limited. With 35.7% (n = 55/154) of orthopaedic surgeons unhappy with their current supports, further studies are required to help inform the orthopaedic community with respect to support choice. Going forward, new supports for stabilising the pelvis or affordable intra-operative techniques for monitoring pelvis stabilisation are required.



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Table 1. Primary guidance approach for obtaining intra-operative acetabular a) inclination and b) version.

	<b>Approach</b>	<b>n / 154</b>	<b>%</b>
<b>Operative Inclination</b>	Mechanical Alignment Guide	78	50.6
	Freehand	48	31.2
	Internal Landmarks	24	15.6
	Computer Aided Surgery	2	1.3
	Other	2	1.3
<b>Operative Version</b>	Transverse Acetabular Ligament	82	53.2
	Freehand	38	24.7
	Mechanical Alignment Guide	24	15.6
	Other Internal Landmarks	10	6.5

## **Figure Legends**

Figure 1: Intra-operative a) adduction and b) internal rotation increase true operative inclination over apparent operative inclination.

Figure 2: Antero-posterior view of pelvis showing radiographic acetabular inclination (RI) and version (RV).

Figure 3: Surgical THA experience of UK orthopaedic surgeons as a function of the number of procedures performed per year and years in practice.

Figure 4: a) Anterior and b) Posterior surgical hip supports used in practice.









