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Pennington, N, Redmond, A, Stewart, T et al. (2014) The impact of surgeon handedness in total hip replacement. *Annals of the Royal College of Surgeons of England*, 96 (6). 437 - 441 (5). ISSN: 0035-8843

<https://doi.org/10.1308/003588414X13946184902488>

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Title: The Impact of Surgeon Handedness in Total Hip Replacement

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Keywords: Hip, Arthroplasty, Surgeon Handedness, Leg Length Inequality, Acetabulum

Abstract

INTRODUCTION Total Hip Replacement (THR) is successful and commonly performed; component placement is a determinant of outcome. Influence of surgeon handedness on component placement has not previously been considered. This study is a radiographic assessment of component positioning with respect to handedness, we report early data from 150+ patients.

METHODS 160 primary THRs for osteoarthritis were included. Equal numbers of left and right THRs were performed by one of four surgeons, two right-handed and two left-handed. Post-operative radiographs were assessed for THR component position by measurement of Leg Length Inequality (LLI), acetabular inclination and centre-of-rotation position. Surgeons' handedness was assessed using the Edinburgh Inventory.

RESULTS For leg length inequality no significant interaction was seen between hip side and surgeon handedness. Acetabular inclination angles showed a statistically significant difference however depending on hand dominance; with higher inclination angles recorded when operating on the dominant side. There was a trend toward greater medialisation of the centre of rotation on the dominant side although this did not reach statistical significance.

DISCUSSION: Variation in acetabular component position, dependent on surgeon handedness has been demonstrated. Although early data, surgeon factors are likely to account for a significant amount of variation seen in surgical outcomes compared to implant design and patient factors, and awareness of the contribution handedness may play is important.

CONCLUSION Surgeon handedness appears to influence acetabular component position during THR, but is one factor of many that interact to achieve a successful outcome.

Introduction:

Component placement and minimisation of leg length inequality (LLI) are key determinants of functional outcome in Total Hip Replacement (THR). Orthopaedic surgeons operate on both sides of patients' bodies yet the effect of surgeon handedness on outcome has not been studied. The spatial position of the patient and surgeon will differ depending on which side of the body the THR is being performed, thus a surgeon's handedness may influence the technical level they are able to operate at, depending on whether they operate on a left or right limb. During THR for a right-handed surgeon performing a right-sided joint acetabular preparation is lead by the dominant right hand whilst femoral preparation is performed by the non-dominant left hand; during a left THR this relationship will be reversed. We use "dominant side" to be a right THR for a right-handed surgeon and a left THR for a left-handed surgeon. This proposed relationship should be unaffected by patient position or surgical approach.

The purpose of this study was to investigate whether surgeon handedness had any influence on THR component positioning based on post-operative radiographs. We present the early data from analysis of 160 cases in the first study to consider this potentially important factor.

Materials and Methods:

Four orthopaedic surgeons (≥ 100 cases per year) and 160 patients were recruited retrospectively at Leeds Teaching Hospitals NHS trust. Stated handedness and preferred surgical approach for each surgeon were:

- **Surgeon 1** = Right-handed and Posterior approach

- **Surgeon 2** = Left-handed and Posterior approach
- **Surgeon 3** = Right-handed and Lateral approach
- **Surgeon 4** = Left-handed and Lateral approach

For each surgeon twenty right THRs and twenty left THRs were identified from theatre records and surgeons' logbooks. Inclusion criteria for patients in the study were a diagnosis of osteoarthritis, non-complex "Primary Total Hip Replacement", post operative AP (anterior-posterior) pelvis radiograph available for review on PACS (Picture Archiving and Communication System - IMPAX 6, Agfa Healthcare, Belgium) and surgeon 1-4 listed as primary operating surgeon.

For each patient the AP radiograph was assessed using linear and angular measurement tools within the IMPAX software. Measurements evaluated LLI (compared to contralateral hip, be it native or prosthetic), acetabular component angle of inclination and THR Centre of Rotation (COR).

LLI was assessed using the Leeds Method (see figure 1) ¹, with a line connecting the femoral heads' CORs as a reference line, and two further lines parallel to this at the inferior aspects of the acetabular teardrops and midpoint of the lesser trochanters. Two perpendicular measurements were made on each hip; first from the reference line to the acetabular teardrop to assess the contribution of the acetabular component to overall LLI. The second measurement from the acetabular teardrop line to the lesser trochanter line provided an assessment of the femoral stem component's contribution to LLI. The overall leg length is the

sum of these two measurements and was compared between the ipsilateral and contralateral hips to provide an overall assessment of any LLI.

Acetabular component inclination angle was assessed using Pluot et al's ² technique with an ischial tuberosity reference line and measuring the angle subtended between this and a line joining the superior and inferior aspects of the acetabular cup (see figure 2).

COR was assessed using a vertical reference line from the pubic symphysis to the sacral spinous processes, the perpendicular distance from this reference line to the COR of the femoral head was measured bilaterally.

Where operative records allowed, comparison of the actual femoral head component size to the radiographic measurement was made and a magnification artefact coefficient was calculated. A mean magnification artefact of 4.9mm was seen (SD = 0.68, 95% CI = 0.30). For example, where a 28mm head had been used the mean measured diameter was 32.9mm and from this the magnification factor (*MF*) was calculated:

$$MF = \frac{32.9}{28} = 1.1755$$

The reduction factor (*RF*) to be applied to each measured value (*MV*) to obtain the "actual value" (*AV*) was determined by:

$$RF = \frac{1}{MF} = \frac{1}{1.1755} = 0.8506$$

$$AV = MV \times 0.8506$$

Correction for magnification was applied to all subsequent measured linear values obtained from the radiographs. All results described in this paper relate to the “corrected” actual values.

Surgeon handedness was assessed using the Edinburgh inventory ³, a Laterality Quotient (LQ) was calculated to provide an assessment of the degree of handedness:

$$LQ = \frac{RHD \text{ responses} - LHD \text{ responses}}{RHD \text{ responses} + LHD \text{ responses}} \times 100$$

All data was transferred to Microsoft Excel for Mac 2011. Statistical analyses were performed using IBM Statistics version 19 (IBM Corp New York, USA).

Results:

Analysis of Total LLI revealed for the dominant operated side a mean (95%CI) LLI of +0.5mm (-0.6 to 1.6mm) and for the non-dominant side a mean LLI of 0.0mm (-1.3 to 1.2mm). Statistical analysis using student’s t-test revealed this to be non-significant (p = 0.543). The absolute LLI mean was 3.6mm (CI 2.9 to 4.4mm) for the dominant side and 4.4mm (CI 3.6 to 5.2mm) for the non-dominant side; Student’s t-test revealed this to be non-significant (p = 0.18).

Mean cup-related LLI on the dominant operated side was -0.4mm (-1.4 to 0.6) and for the non-dominant side -1.5mm (-2.3 to -0.6); this result approached but

did not reach statistical significance ($p = 0.096$). Absolute cup-related LLI was 3.6mm (CI 3.0 to 4.2mm) for the dominant side and 3.3mm (CI 2.8 to 3.8mm) for the non-dominant side; t-test revealed this to be non-significant ($p = 0.422$).

Mean femoral stem-related LLI was +0.9mm (-0.7 to 2.4mm) on the dominant operated side and +1.4mm (-0.1 to 2.9) on the non-dominant side; this was not statistically significant ($P = 0.593$). Absolute stem-related LLI mean was 5.5mm (CI 4.6 to 6.5mm) for the dominant side and 5.5mm (CI 4.5 to 6.4mm) on the non-dominant side; t-test showed this to be non-significant ($p = 0.948$).

Analysis of absolute total LLI with regard surgical approach was considered; a mean of 5.1mm (CI 4.2 to 6.0mm) for the posterior approach and 5.9mm (CI 4.9 to 6.9mm) for the anterolateral approach was seen; t-test showed this to not be statistically significant ($p = 0.233$) (Figure 3).

Stratified LLI data for each of the four surgeons showed that variability in the distribution of LLI values appeared to exist; see figures 4a, 4b, 4c and 4d. Surgeons 1 and 3 (right-handed) showed a trend to lower LLIs when femur preparation was lead by their dominant hand. In surgeon 4 (left-handed), increased variability in stratified LLI data was observed when femoral preparation was led by their non-dominant hand. Surgeon 2 (left-handed) showed comparable stratified LLI results irrespective of side.

Analysis of inclination angle of the acetabular component revealed a mean of 46.4° (45.4 to 47.4) on the dominant operated side and 43.5° (42.3 to 44.6) on the non-dominant side; this was statistically significant ($p < 0.05$) see figure 5.

Consideration of COR revealed on the dominant operated side a mean medialisation of 0.4mm (1.6 to -0.7) compared with a mean medialisation on the non-dominant side of 1.7mm (2.7 to 0.7); this result approached but did not reach statistical significance ($p = 0.098$).

Results of the Edinburgh Inventory questionnaire are shown in the Table 1. Surgeons 1 and 3 declared to be right-handed and their Edinburgh Inventory LQs support this with values of +100 and +78.6 respectively. The results of surgeons 2 and 4 support their declared left-handedness with LQs of -50 and -100 respectively.

Discussion:

LLI is an established complication of THR and the overall mean LLI in this study was lower than that found by Konvoyes et al ⁴ where a mean lengthening of 3.5mm was observed. Surgeon handedness did not show any statistically significant difference in total LLI between THRs performed on the dominant and non-dominant sides. A trend toward LLI “shortening” in the acetabular component was seen, reflecting relative superior positioning, and appeared more marked when the THR was performed on surgeons’ non-dominant side. Results also suggest that acetabular component positioning may be more susceptible to variation when performed on a surgeon’s non-dominant side with statistically significant lower angles of inclination seen, along with a tendency for increased medialisation that approached statistical significance. Variability in

acetabular component insertion position dependent on surgeon handedness appears to exist; a larger study is warranted to explore trends in this study that did not reach significance. Observation of a systematic difference in acetabular inclination is of interest, although the small angle (3°) seen is unlikely to be clinically significant. Both groups were within Lewinnek et al's ⁵ safe zone of 30-50°. During THR on the opposite side of the body to the surgeon's dominant hand acetabular preparation is lead by the surgeon's non-dominant hand, whilst femoral preparation and component insertion by their dominant hand. One explanation for the observed differences in cup medialisation may be that surgeons exert more pressure and increasingly deepen the acetabulum when operating power reamers with their non-dominant hand, at the same time allowing relatively superior positioning of the cup. It would also be interesting to consider these observed changes in a future study in comparison to the results obtained in investigations of computer guided arthroplasty outcomes.

The Edinburgh inventory used is a validated method of assessing hand dominance and degree of handedness ³. The LQs for the four surgeons support their subjective "handedness". The left-handed surgeons (2 and 4) showed negative LQ values, but for surgeon 2 they showed a less strong handedness preference. This may reflect that left-handed individuals will display a less polarized LQ value, as many aspects of everyday life are right-hand dominant biased ³. Thus left-handed individuals have a societal pressure to use their non-dominant, right hand, more than right-handed individuals would be to use their left hand. A larger study would be necessary to make the use of handedness LQ data in statistical analysis relevant.

No literature exists specifically looking at whether surgeon handedness affects performance depending upon which side of the body a THR is performed. Mehta et al ⁶ considered a single surgeon series of 728 total knee replacements, half left and half right, performed by a right-handed surgeon. Post-operative function and pain scores showed that handedness did appear to play a role in outcome. Makay et al's ⁷ questionnaire based study of general surgeons with respect to left-handedness found 9.3% of surgeons were left-handed and 50% felt that standard endoscopic surgical techniques had to be modified for the left-handed surgeon. Gallagher et al ⁸ considered the roll of spatial awareness in a study of urologists, concluding it is only one component of the successful development of surgical skills alongside intelligence, dexterity, experience, decision-making and personality.

There are several limitations to the current study. The observed values and differences are small and a larger study would be required to determine whether a true systematic effect exists where we found trends. A single person collected all data, and so no-cross checking occurred, although the Leeds method of LLI assessment has been shown to be accurate and to have good repeatability ¹. The potential effect of pelvic tilt on pelvic radiograph appearance has not been controlled for.

This study presents early data, surgeon factors are likely to account for a significant amount of variation seen in outcomes when compared to implant design and patient factors, and awareness of the potential contribution handedness may play is important.

Conclusion

THR post-operative parameters have been considered in an attempt to objectify technical surgical outcome in terms of component position. These results have been assessed in the context of surgeon handedness and the side of the patient that the procedure was performed on. Overall technical performance of a THR by any surgeon is the product of a multitude of factors, some related to the surgeon's inherent attributes and others the individual character of each case. This study's results suggest that handedness is one of these factors, especially with regard the acetabular component. While the observed effect was modest, it has not been demonstrated previously and warrants consideration when performing a THR on the non-dominant side of the body.

Word count = 1,981

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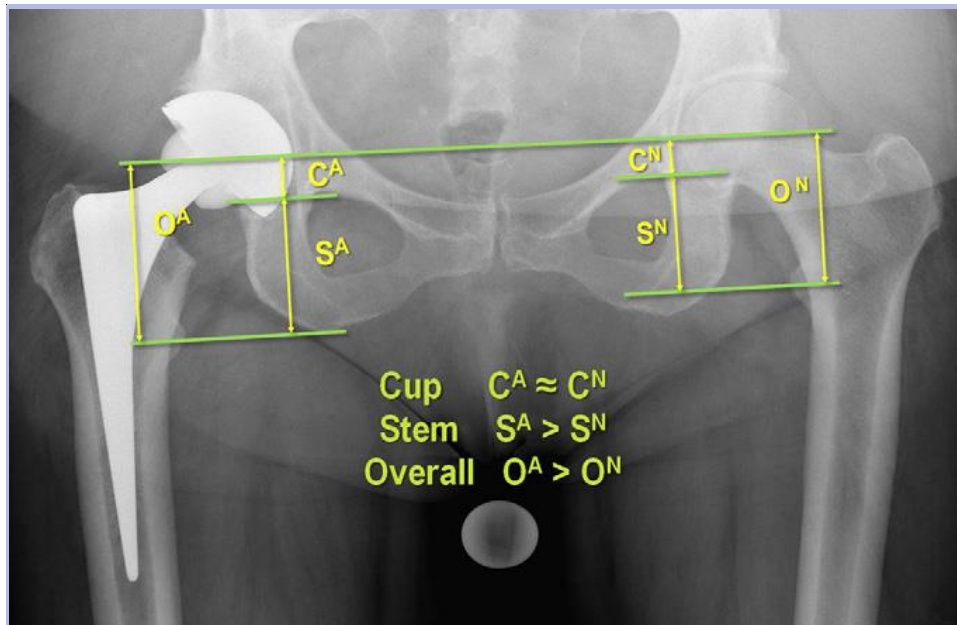


Figure 1 - Leeds Method of Leg Length Inequality Assessment (McWilliams et al 2011).

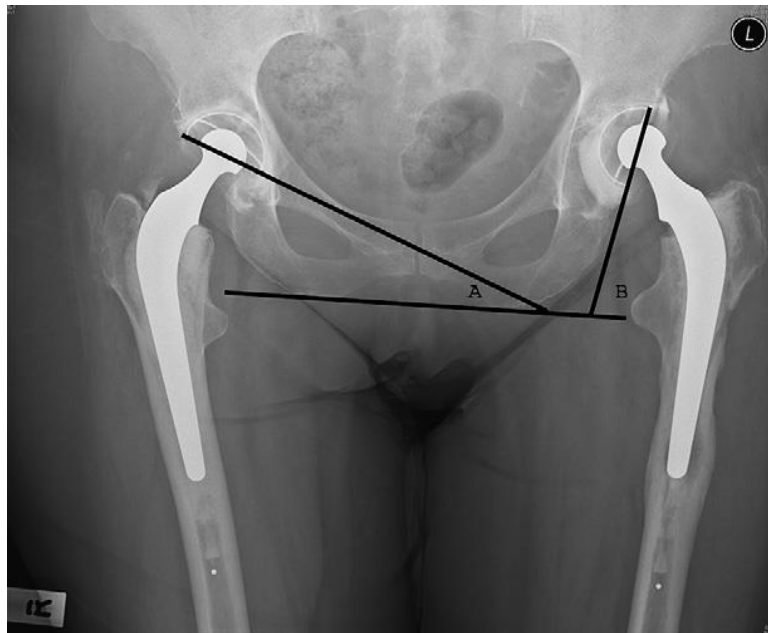


Figure 2 - Acetabular Inclination angle assessment method (Pluot et al 2009).

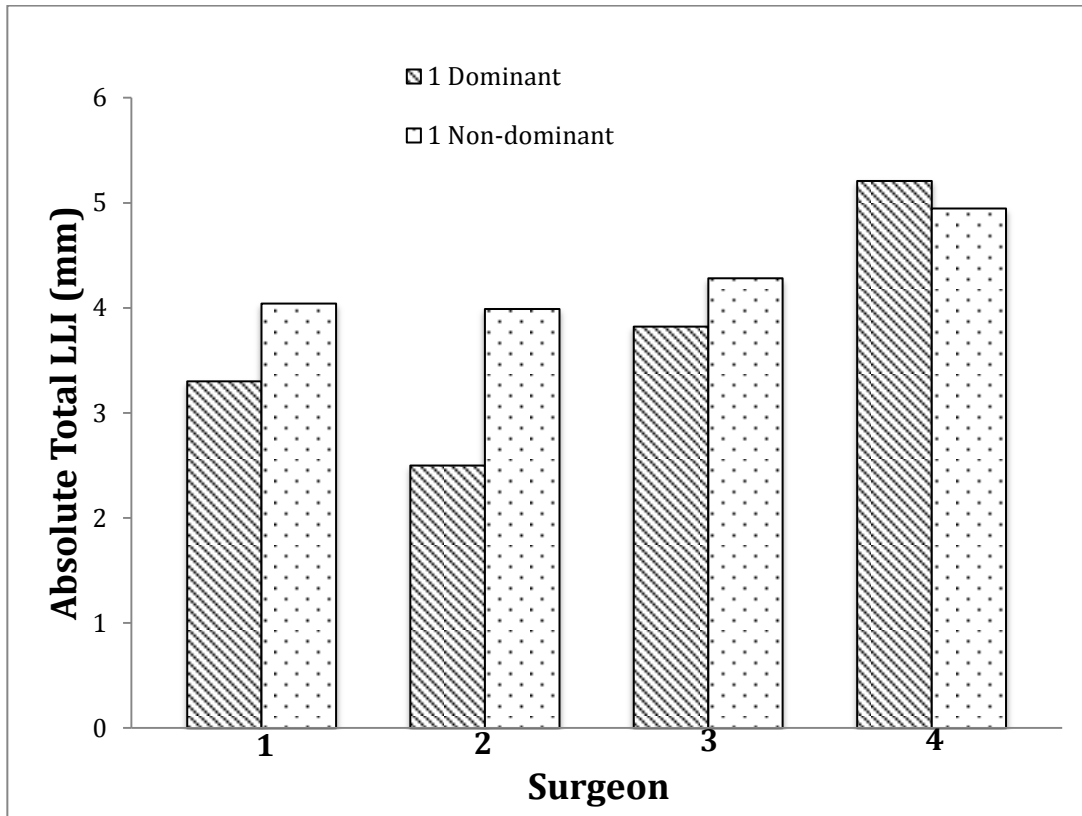


Figure 3 - Histogram of Mean Absolute Total LLI for the dominant (a) and the non-dominant (b) hands of four surgeons.

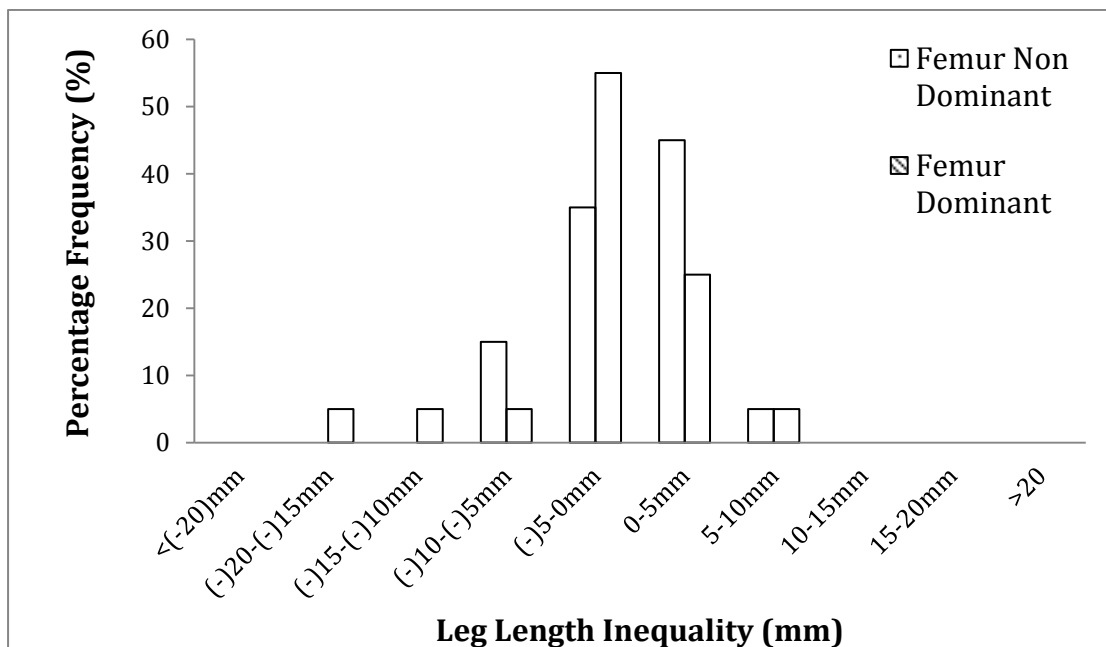


Figure 4a- Stratified LLI data for Surgeon 1 showing relationship to handedness of femur preparation

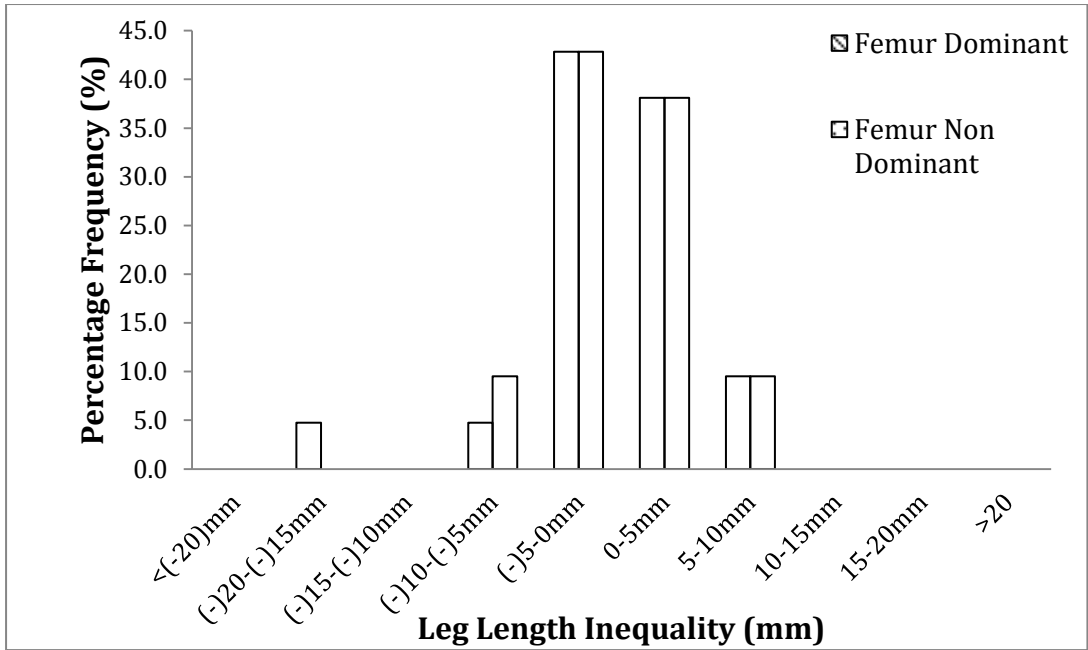


Figure 4b - Stratified LLI data for Surgeon 2 showing relationship to handedness of femur preparation

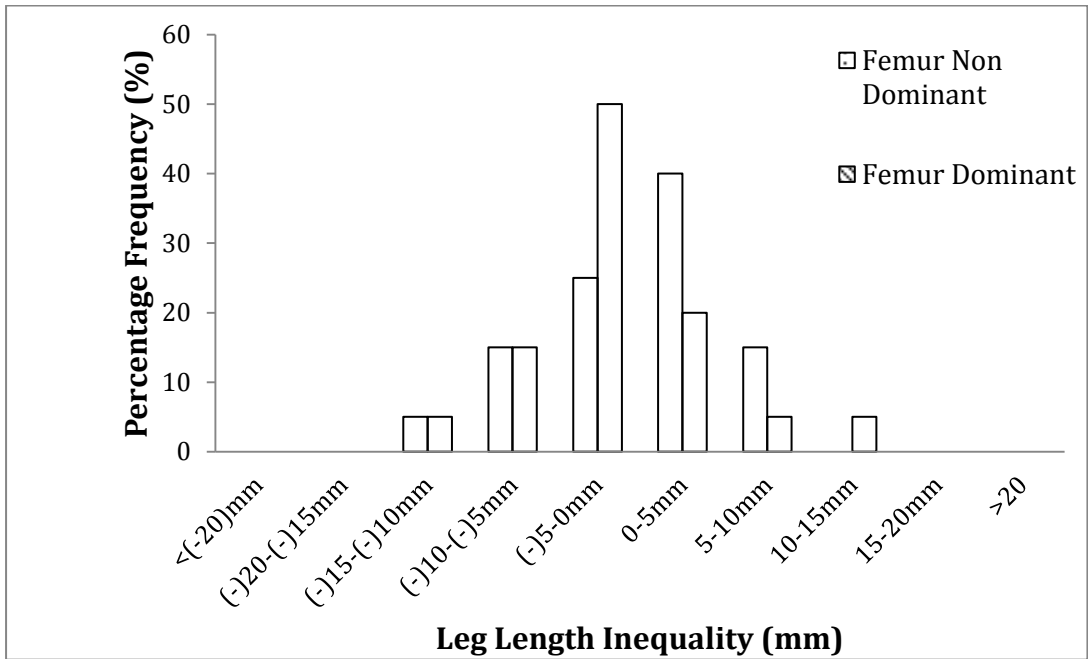


Figure 4c - Stratified LLI data for Surgeon 3 showing relationship to handedness of femur preparation

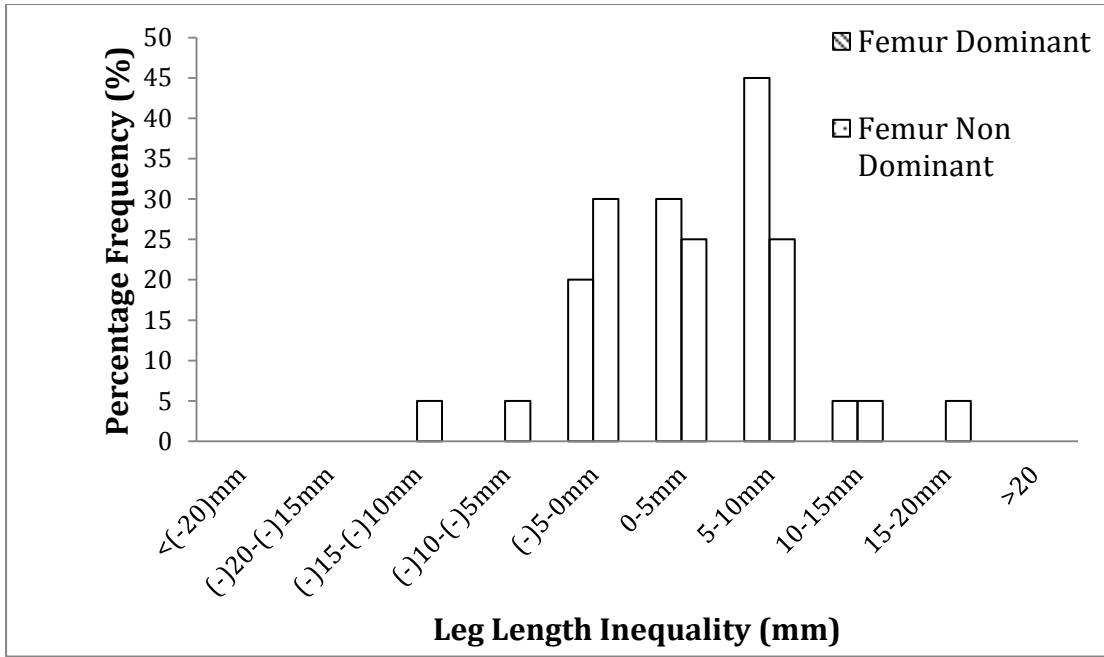


Figure 4d - Stratified LLI data for Surgeon 4 showing relationship to handedness of femur preparation

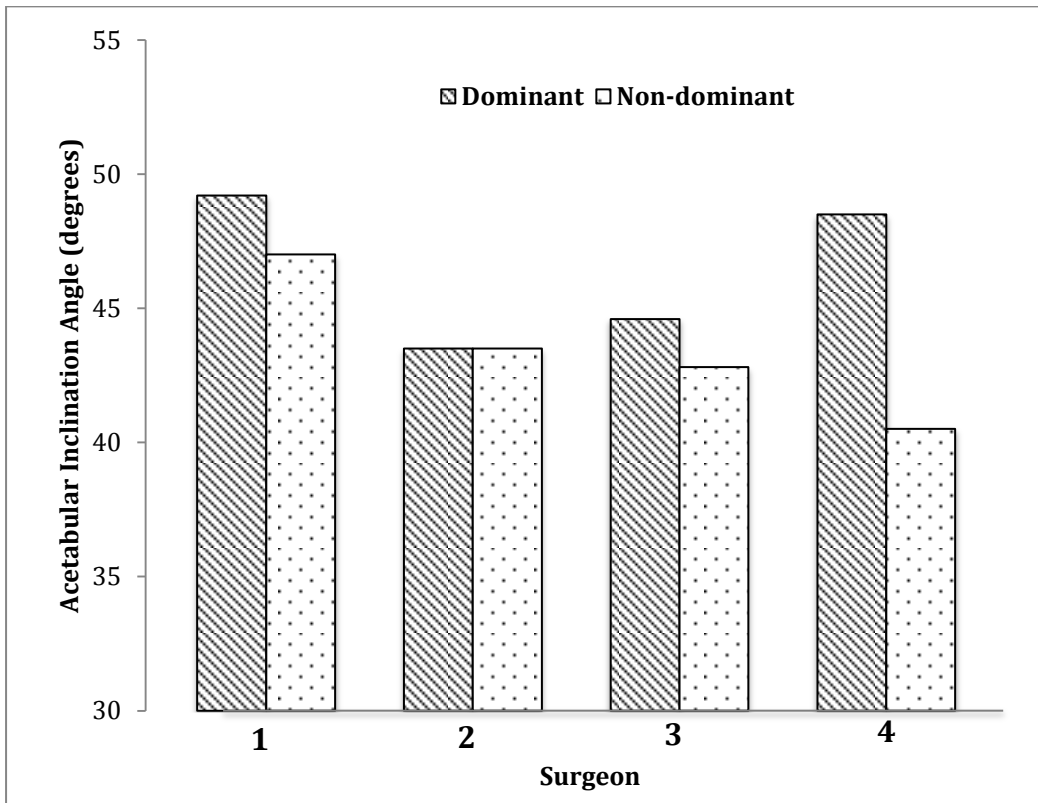


Figure 5 - Mean Acetabular Inclination angle for the dominant and non-dominant hands of each of the four surgeons.

Table 1. Edinburgh Inventory Handedness Assessment. A value of 100 refers to an individual with strong handedness.

| Surgeon | Declared Handedness | Edinburgh Inventory Laterality Quotient |
|----------------|----------------------------|--|
| 1 | Right | +100 |
| 2 | Left | -50 |
| 3 | Right | +78.6 |
| 4 | Left | -100 |