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# NON-INVASIVE ASSESSMENT OF LOWER LIMB ALIGNMENT IS ACCURATE FOR PRE-OPERATIVE PLANNING AND POST-OPERATIVE FOLLOW UP

J.V. Clarke[1,2], F. Picard[2], P.E. Riches[1], A.H. Deakin[1,2]

1. Department of Bioengineering, University of Strathclyde, Wolfson Building, 106 Rottenrow , Glasgow, G4 0NW

2. Department of Orthopaedics, Golden Jubilee National Hospital, Clydebank

**Introduction:** Knee alignment is a fundamental measurement in the assessment, monitoring and surgical management of patients with OA. Recent controversy about the effect of knee alignment on long term total knee arthroplasty survivorship [1] has revived the debate with regard to the effective measurement of knee alignment. In the absence of validated alternatives, leg alignment is currently commonly assessed with either short knee or long leg radiographs, both of which may be inaccurate. Three dimensional imaging obtained with CT or MRI scans can provide higher levels of accuracy but is less readily available, provide supine-only measurements and, similar to radiographs, assess alignment as a static parameter. To overcome these limitations, we have developed a non-invasive measurement technique with the view to more accurately assessing lower limb alignment under a number of dynamic, real-time conditions at any stage of patient assessment [2].

The purpose of this study was to compare non-invasive supine measurements of alignment in osteoarthritic and prosthetic knees taken pre- and post-operatively to those data gathered intra-operatively using standard invasive methods. The hypothesis was that the measurements taken in the clinic would be accurate enough to enable pre-operative planning and longer term follow-up.

**Materials and Methods:** A non-invasive infrared position capture system (accuracy ±1° in both coronal and sagittal plane) [2] was used to assess the knee alignment for 31 patients with OA, within four weeks before and at six weeks following TKA. Coronal and sagittal mechanical femorotibial (MFT) angles in extension were measured with each subject supine, the lower limb was supported at the heel and the subject asked to relax. Varus and valgus stresses were applied to the knee and the resultant MFT angles recorded. Intra-operatively the same data were collected both pre- and post-implant as per the standard practice of the surgeon. This gave data from the invasive and non-invasive systems for both osteoarthritic (OA) and prosthetic (TKA) knees. The results for invasive and non-invasive measurements were compared using paired t-tests.

**Results:** For both OA and TKA knees, the mean difference in coronal MFT angle between the non-invasive and invasive measurements was small (0.5°) and not clinically or statistically significant (Table 1). For the sagittal MFT angles there was a significant difference between non-invasive and invasive measures for both OA and TKA knees (Table 1). For the OA knees, the intra-operative measurements were in greater relative extension (mean -5.2°) in comparison to the non-invasive measurements. The post-implant TKA invasive measurements had an even greater tendency (-7.2°) to more extension when compared to the non-invasive post-operative clinical measurements.

**Table 1:** Comparison of non-invasive and invasive alignment measurements for pre-operative (OA) and post-operative (TKA) patient groups. **Negative values indicate varus in the coronal plane and hyperextension in the sagittal plane.**

| | | mean(95%CI)±SD | |
|---|---|---|---|
| | | **OA (n=31)** | **TKA (n=29)** |
| **Supine coronal MFT angle (°)** | **Non-invasive** | -2.5(-4.6,-0.4)±5.7 | -0.7(-1.2,-0.1)±1.4 |
| | **Invasive** | -2.0(-4.0,0.2)±5.7 | -0.2(-0.6,0.2)±1.1 |
| | **Difference** | 0.5(-0.5,1.5)±2.8 | 0.5(-0.1,1.0)±1.4 |
| | **p value** | 0.3 | 0.08 |
| **Supine sagittal MFT angle (°)** | **Non-invasive** | 7.7(5.1,10.4)±7.1 | 6.7(4.8,8.7)±5.1 |
| | **Invasive** | 2.5(-0.3,5.3)±7.7 | -0.5(-1.8,0.7)±3.3 |
| | **Difference** | -5.2(-6.8,-3.7)±4.3 | -7.2(-9.0,-5.4)±4.7 |
| | **p value** | $<0.001$ | $<0.001$ |

For OA knees, both varus and valgus stress manoeuvres resulted in statistically greater angular displacements for the invasive measurements (mean differences 1.5° more varus and 1.6° more valgus) compared to the non-invasive measures (Table 2). For the TKA knees, the valgus angular displacement was statistically greater for the invasive intra-operative measurements but for varus angular displacement the two measurement conditions were statistically similar with a mean difference of 0.3° (Table 2).

**Table 2:** Comparison of non-invasive and invasive coronal laxity for pre-operative (OA) and post-operative (TKA) patient groups

| | | mean(95%CI)±SD | |
|---|---|---|---|
| | | **OA (n=30)** | **TKA (n=28)** |
| **Varus angular displacement (°)** | **Non-invasive** | -3.8(-4.4,-3.3)±1.5 | -4.3(-4.8,-3.9)±1.1 |
| | **Invasive** | -5.3(-6.3,-4.5)±2.2 | -4.1(-4.6,-3.5)±1.4 |
| | **Difference** | -1.5(-2.4,-0.6)±2.4 | 0.3(-0.3,0.8)±1.4 |
| | **p value** | 0.002 | 0.3 |
| **Valgus angular displacement (°)** | **Non-invasive** | 3.3(2.7,3.9)±1.6 | 2.8(2.5,3.1)±0.8 |
| | **Invasive** | 5.0(4.4,5.5)±1.6 | 3.7(3.2,4.2)±1.3 |
| | **Difference** | 1.6(1.1,2.2)±1.6 | 0.9(0.4,1.4)±1.3 |
| | **p value** | $<0.001$ | 0.002 |

**Conclusions:** The invasive OA and TKA coronal MFT angles were more valgus than the corresponding non-invasive measurements by a mean difference of 0.5°. This trend, although neither clinically or statistically significant in the context of overall knee alignment, may have represented the effect of the medial surgical exposure in most cases with potential loss of valgus restraint. In contrast to the coronal measurements, the sagittal MFT angles were significantly different for clinical and operative conditions. In the pre-operative clinical setting, muscular contraction could have potentially restricted the amount of knee extension if this was painful. The removal of this muscular inhibition along with exposure of the knee resulted in a more extended intra-operative position. This was a similar finding in the TKA group, with an even greater degree of relative hyperextension for the invasive measurements.

During pre-operative clinical assessment, the limiting factor during stress testing may have been the discomfort of the manoeuvre rather than the perception of a definitive end-point. Therefore muscular inhibition during stress testing, which was absent intra-operatively, most likely accounted for the greater overall mean values of the invasive measurements. The effect of the medial exposure of the knee may have influenced the degree of valgus angular displacement, although the magnitude of the difference between non-invasive and invasive measurements was the same for both medial and lateral laxity. Another factor could be the intra-articular pressure that coapts joint that is not present in open knees. Following TKA the trends suggest that the difference between the intra-operative and post-operative valgus stress measurements was not the result of pain inhibition as this same trend would have then been expected. The results suggest that the intra-operative varus laxity is likely to be the same when measured at the six week post-operative stage. However the intra-operative valgus laxity may be around 1° less when measured at six weeks. This could have been due to the effect of wound closure with contraction of the medial tissues as part of the normal acute healing process [3] or the pes ansirinus/hamstring contracture known for limiting accurate knee examination in medial ligament injury.

Overall the measurements taken in the clinic would have enabled accurate pre-operative planning as long as the increase in extension seen intra-operatively was accounted for. Surgeons may be advised that post-operatively the extension seen is less than that measured post-implant and to adjust their aims accordingly. Further investigations are now envisaged using this reliable system to assess lower limb alignment to determine whether intra-operative outcome is maintained over the time.

**References**

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3. **Hardy MA.** The biology of scar formation, *Phys Ther 1989*;69:1014-1024