ASSESSMENT OF CORONAL MECHANICAL ALIGNMENT WITH APPLIED VARUS AND VALGUS FORCE THROUGH THE RANGE OF FLEXION USING NON-INVASIVE NAVIGATION

Fraser Henderson[1,2], Roberto Alho[1,2], Angela Deakin[1,2], Philip Riches[2], Frederic Picard[1,2]

[1] Golden Jubilee National Hospital, Clydebank, G81 4DY, United Kingdom, frederic.picard@gjnh.scot.nhs.uk

[2] University of Strathclyde, Glasgow, G4 0NW, United Kingdom

INTRODUCTION

Key goals of total knee arthroplasty include the correction of knee malalignment in the coronal plane and achieving a 'balanced' knee with satisfactory stability through the range of motion with applied varus and valgus force. Previous studies have proposed algorithms, based on navigation technology, to quantify soft-tissue knee balancing and thus give an objective measure in this technical aspect of arthroplasty (Picard 2007). A reliable, non-invasive navigation measure of mechanical alignment with applied force could be a valuable tool in pre-operative planning and post-operative follow-up. We aimed to validate, in vivo, the measurement of on-screen, real-time mechanical femorotibial angle (MFTA) through the range of flexion with manually applied varus and valgus force. Our non-invasive system has been previously validated as reliable and repeatable for measurement of supine MFTA in extension (Clarke 2012). In a further cadaveric study, it was found to have satisfactory agreement with a conventional, invasive navigation system in measuring MFTA with applied varus or valgus force for the range of flexion 0°-30° (Russell 2014).

MATERIALS AND METHODS

Ethical approval was granted for use of the non-invasive navigation system and 23 volunteers with normal knees, mean age 33 years (range 23-59), were recruited. The non-invasive system consisted of infra-red Spectra camera (NDI), navigation base-plates secured to the skin surface with fabric strapping, navigation pointer, passive trackers and Physiopilot 1.0 non-invasive navigation software (BBraun Aesculap). Two passive trackers were placed, one over the distal femur and one over the proximal tibia, and surface bony landmarks were registered in the Physiopilot workflow. Each volunteer was examined by two clinicians, with each operator performing two registrations on each knee. The range of laxity in the coronal plane (change in MFTA) was measured with each operator applying a manual force to the knee to the endpoint of both varus and valgus displacement throughout the range of motion (0°, 15°, 30°, 45°, 60°, 75° and 90°).

The reliability of the non-invasive system was evaluated by calculations of Coefficient of Repeatability and Interclass Correlation Coefficient for intra-observer and inter-observer repeatabilities, respectively. An acceptable limit of agreement was taken as ±3° (Berend 2004).

RESULTS

For the first eight volunteers the agreement of the measured MFTA in extension for the 2 registrations was found to be outlying acceptable limits and therefore the final 15 volunteers were analysed (30 normal knees). The system showed good intra-observer repeatability in extension; however this became poor as the knee was flexed. Reliability results with applied varus and valgus force are shown in Tables 1 and 2.

Flexion Angle	Applied Varus Force	Applied Valgus Force
0°	2°	2°
15°	7°	9°
30°	11°	12°
45°	17°	11°
60°	17°	12°
75°	16°	10°
90°	13°	14°

Table 1: Intra-observer repeatabilities (CR)

Flexion Angle	Applied Varus Force	Applied Valgus Force
0°	0.70	0.71
15°	0.45	0.50
30°	0.61	0.72
45°	0.57	0.61
60°	0.64	0.61
75°	0.51	0.38
90°	0.65	0.61

Table 2: Inter-observer repeatabilities (ICC)

DISCUSSION

In keeping with previous studies, the non-invasive navigation system was able to give a reliable measurement of MFTA in extension. However, with flexion beyond 0°, clinical assessment of MFTA fell outwith the acceptable limits for CR and ICC. We believe that difficulties in examining the knee during flexion with navigation trackers attached are a potential source of error. Our study was limited in that the applied varus and valgus forces were not standardised, with the knee taken to a subjective endpoint of laxity by each examiner manually applying force. Unfortunately it was not technically feasible at this stage in this study to incorporate a tracked force application device with the Physiopilot non-invasive software. We propose that further studies with standardised force application are required to address the errors incurred in measuring MFTA with non-invasive navigation when flexion is introduced. We believe that the outlying results found on our first 8 volunteers represent a learning curve in using the non-invasive system, a phenomenon in the use of knee navigation which has been described in the literature [Donnelly 2004].

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DISCLOSURES

Mr F Picard has licences and patents with BBraun Aseculap. The Golden Jubilee National Hospital receives grants from BBraun Aesculap.