Total knee replacement using the measured resection technique: do we get it right by accident?

ND Clement*

Abstract

Introduction

The following question is often asked: why does the measured resection technique result in a balanced total knee replacement despite measuring from an eburnated joint surface distally and a cartilage-covered condyle posteriorly. The presented hypothesis is that the distal femoral bone-cut is distalised on average by 2 mm when measured relative to the medial condyle. This is due to the change in the distal condylar angle of approximately 3° and results in a differential distal bone-cut. This 2 mm distalisation of the femoral component compensates for using the cartilage-covered, posterior condyle as a reference point when using the measured resection technique. This article hypothesises why the measured resection technique works in total knee replacement.

Conclusion

Although the hypothesis is supported, implementing it into clinical practice is yet to be observed and requires further research.

Introduction

Two techniques are employed when implanting a total knee replacement (TKR), that of gap-balancing and measured resection. In the measured resection technique, the remaining joint surface is used as a reference point from which the positions of the bony cuts are calculated. There is a vast amount of literature addressing the rotation of the femoral component with regard to the transepicondylar line, as rotation of the component affects stability in flexion and the kinematics at the tibiofemoral and patellofemoral joints. However, there has been minimal attention given to the effect of measured resection upon gap-balancing. If it is accepted that the distal femoral bone-cut is measured relative to the eburnated surface, due to the full thickness loss of the cartilage and hence the indication for the TKR, then this must be different from the posterior condylar measure. When the posterior condylar bone-cuts are measured, it is not done in relation to the bony eburnated surface, but the preserved cartilage-covered surface due to minimal wear in this relatively non-weight bearing aspect of the knee. A recent study of osteoarthritic knees demonstrated that the cartilage over the posterior condyles was preserved and measured approximately 2 mm in thickness. Also, this 2 mm measurement is consistent with the cartilage thickness in asymptomatic knees. Hence, if it is accepted that the posterior condylar bone-cuts are measured relative to the cartilage-covered posterior condyles, in contrast to the eburnated distal condyle, then there will be at least a 2 mm difference in the extension and flexion gaps when using the measured resection technique. This should result in a loose extension gap or a tight flexion gap, but this does not seem to occur with good functional results that are equal to that of the gap-balancing technique.

This article presents a hypothesis on why the measured resection technique works and results in a balanced TKR, and discusses the potential implications if the parameters of this hypothesis are not observed. The anatomy of the distal femur is discussed first to support the hypothesis. We have also discussed how the anatomy of the distal femur results in a differential distal femoral bone-cut that matches the posterior condylar bone-cut made relative to the cartilage-covered surface.

The distal femoral condylar angle

Coronal alignment of the femur can be measured from the angle formed between a tangential line across the distal femur and the anatomical axis of the femur, which is termed as the distal condylar angle (Figure 1). The mean value of this angle is 81° with no significant differences with respect to gender or disease type. Due to the current convention of making the bony tibial cut at 90° to the anatomical axis of the tibia, in the coronal plane addressing the rotation of the femoral component with regard to the transepicondylar line, as rotation of the component affects stability in flexion and the kinematics at the tibiofemoral and patellofemoral joints. However, there has been minimal attention given to the effect of measured resection upon gap-balancing. If it is accepted that the distal femoral bone-cut is measured relative to the eburnated surface, due to the full thickness loss of the cartilage and hence the indication for the TKR, then this must be different from the posterior condylar measure. When the posterior condylar bone-cuts are measured, it is not done in relation to the bony eburnated surface, but the preserved cartilage-covered surface due to minimal wear in this relatively non-weight bearing aspect of the knee. A recent study of osteoarthritic knees demonstrated that the cartilage over the posterior condyles was preserved and measured approximately 2 mm in thickness. Also, this 2 mm measurement is consistent with the cartilage thickness in asymptomatic knees. Hence, if it is accepted that the posterior condylar bone-cuts are measured relative to the cartilage-covered posterior condyles, in contrast to the eburnated distal condyle, then there will be at least a 2 mm difference in the extension and flexion gaps when using the measured resection technique. This should result in a loose extension gap or a tight flexion gap, but this does not seem to occur with good functional results that are equal to that of the gap-balancing technique.

Figure 1: Distal condylar angle (X) formed by a tangential line across the distal femur and a line marking the anatomical axis of the femur, which has a mean value of 81°.

*Corresponding author
Email: nickclement@doctors.org.uk
Department of Orthopaedics and Trauma, The Royal Infirmary of Edinburgh, Little France, Edinburgh, United Kingdom

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plain, the femoral bony cut needs to be adapted to compensate for this factor. The distal condylar angle is changed from 81° to approximately 84° to re-establish the normal femorotibial angle of 174°. This results in a 3° change in the distal condylar angle; for example, the normal distal condylar angle of 9° (X) is changed to 6° (Z) due to the subtraction of the 3° of varus that is corrected for when performing the tibial bony cut (Figures 1 and 2). This change in the distal condylar angle results in a differential bone-cut across the distal femur, with more medial condylar bone being resected compared to the lateral condyle (Figure 2).

Calculating the differential in the distal bone-cut
Using the 3° change in the distal condylar angle and assuming the normal femoral width is 80 mm, this would result in a differential bone-cut from the medial distal femur to the lateral distal femur, in the coronal plane, of 4 mm (Figure 3). Hence, if the eburnated surface of the medial distal femur is used to reference the measured resection, it will result in 4 mm less of a resection at the lateral aspect of the lateral femoral condyle (Figure 4). This differential bone-cut is graduated across the distal femur, so on average there is a 2 mm increase in the measured distal femoral resection. This 2 mm increase is consistent with the thickness of the cartilage that was worn away from the condyle, and more importantly, this balances the flexion and extension gaps, where the posterior condylar bone-cuts were made in relation to the cartilaginous surface which is also 2 mm thick.

Discussion
Although there is a growing wealth of literature regarding femoral rotation, there is paucity in literature analysing the differential distal femoral bone-cut. The novel hypothesis presented here seems to be supported by the bony anatomy of the distal femur and the bony cuts made using the measured resection technique for TKR. If this hypothesis is correct, cases where these parameters are not present would result in a mismatch in the flexion and extension gaps. For example, if the medial compartment of the knee was preserved with isolated lateral arthrosis only, it would result in distalisation of the femoral component and potentially result in a tight extension gap. The converse would also be true; if bone erosion was present at the medial condyle and was used as the reference point, it would result in more bone being excised from the distal femur thus resulting in a tight flexion gap or loose extension gap. In addition, if there was cartilage loss over the posterior femoral condyles (for example, in inflammatory arthropathy) and the eburnated bone was used as a reference point, then this would result in over resection and hence a loose flexion gap.

Conclusion
The presented hypothesis is theoretically supported, but whether this translates into clinical practice cannot be confirmed without further study.

All authors contributed to the concept, design and preparation of the manuscript, as well as read and approved the final manuscript.

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