ABSTRACT

Purpose. To compare the 2-year outcome of total knee arthroplasty (TKA) using the measured resection versus the gap balancing techniques.

Methods. 21 men and 31 women aged 41 to 89 (mean, 73) years who underwent primary TKA by a single surgeon for osteoarthritis and had an American Society of Anesthesiologists I or II physical status were prospectively studied. Patients were randomised to undergo computer-assisted TKA using the measured resection technique (n=26) or the gap balancing technique (n=26). At the 2-year follow-up, patients were assessed by a single orthopaedic registrar blinded to the type of surgery using the Knee Society score (KSS), functional Knee Society score (FKSS), and revised Oxford Knee score (ROKS).

Results. In the measured resection group, the mean KSS, FKSS, and ROKS increased from 34.3, 48, and 21 to 85.9, 89.6, and 36.5, respectively. In the gap balancing group, the respective scores increased from 35.4, 50, and 22.5 to 89.1, 92.4, and 40.6. Postoperative increases in the respective scores were slightly better with the gap balancing technique; the respective p values were 0.46, 0.44, and 0.12.

Conclusion. Improvements in the knee scores were comparable with the 2 techniques.

Key words: arthroplasty, replacement, knee; surgery, computer-assisted

INTRODUCTION

Computer-assisted total knee arthroplasty (TKA) enables precise implant positioning, bony alignment, and soft-tissue balancing; all of which are important for the success of the procedure. It can also estimate the effect of changing one variable on the other at the planning stage. Measured resection and gap balancing are the 2 most common techniques for knee balancing; each has its own advantages and disadvantages. Accurate and reproducible assessment of soft-tissue balance throughout the full range of movement is paramount to achieving a well-balanced knee with improved longevity. Adequate ligament balancing...
is more important in TKA with a rotating platform than with a fixed bearing.\textsuperscript{10} We therefore compared the 2-year outcome of TKA using the measured resection versus the gap balancing techniques.

**MATERIALS AND METHODS**

This prospective, randomised, single-blinded study was conducted between February 2007 and February 2008. Approval was obtained from the local ethics committee. 21 men and 31 women aged 41 to 89 (mean, 73) years who underwent primary TKA by a single surgeon for osteoarthritis and had an American Society of Anesthesiologists (ASA) I or II physical status were prospectively studied. Patients who had inflammatory arthritis, an ASA III or higher physical status, pre-existent ligament injuries, and revision TKA were excluded. Patients were randomised to undergo TKA using the measured resection technique (n=26) or the gap balancing technique (n=26).

TKA was performed through a midline skin incision and a medial parapatellar approach. A tourniquet was used and released after wound closure, with application of pressure dressing. The Pi Galileo navigation system (Smith & Nephew Orthopaedics) incorporated a positioning mini-robot that helped make precise femoral cuts after registration of bony landmarks. The system enabled measured tensioning of soft tissue to achieve precise balance of TKA throughout the range of movement, which was recorded in graphical format. An uncemented, porous-coated, cruciate-retaining, mobile-bearing knee prosthesis (TC Plus SB; Smith and Nephew) was used. The patella was not replaced.

In the measured resection technique, tibial and femoral cuts were made with navigation after registration of important bony landmarks (upper articular surface of the tibia, defects in the tibia, femoral epicondyles, posterior condylar axis, and anteroposterior axis). The aim was to take just enough bone as would be subsequently replaced by the implant. Soft-tissue release was performed if necessary after trial implantation.

In the gap balancing technique, the tibial cut was first made perpendicular to the mechanical axis using computer navigation. Soft-tissue balancing was then assessed in both extension and flexion using a navigated force feedback tensioner. A force of 80 N was used on both the medial and lateral femoral compartments for balancing the flexion and extension gaps. Imbalance in extension was resolved by sequential soft-tissue release to align the leg in extension. In the varus knee, osteophytes, the deep medial collateral ligament, the posteromedial corner with attachment of the semi-membranosus, and the superficial medial collateral ligament were released sequentially as necessary. In the valgus knee, the order of release was osteophytes, the lateral capsule, the iliobibial band, and the lateral collateral ligament. The anterior and posterior femoral bone cuts were made parallel to the tibial cut based on the ligament tension to balance the flexion gap with the extension gap. The force feedback ligament tensioner enabled the gaps to be assessed in mm and the force in N.

At the 2-year follow-up, patients were assessed by a single orthopaedic registrar blinded to the type of surgery using the Knee Society score (KSS), functional Knee Society score (FKSS), and revised Oxford Knee score (ROKS). The ROKS was based on 12 questions involving common activities of daily living. Scores ranged from 0 to 48; higher scores indicated least difficulty. Outcomes of the 2 groups were compared using the paired $t$ test.

### RESULTS

In the measured resection group, the mean KSS, FKSS, and ROKS increased from 34.3 (standard deviation [SD], 13.0), 48 (SD, 12.7), and 21 (SD, 7.9) to 85.9 (SD, 17.6), 89.6 (SD, 14.7), and 36.5 (SD, 9.3), respectively. In the gap balancing group, the respective scores increased from 35.4 (SD, 15.8), 50 (SD, 9.7), and 22.5 (SD, 6.7) to 89.1 (SD, 12.9), 92.4 (SD, 10.4), and 40.6 (SD, 7.9). Postoperative increases in the respective scores were slightly better with the gap balancing technique; the respective $p$ values were 0.46, 0.44, and 0.12 (Table).

<table>
<thead>
<tr>
<th>Score</th>
<th>Measured resection</th>
<th>Gap balancing</th>
<th>$p$ Value</th>
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<tr>
<td>Knee Society score</td>
<td></td>
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<td>Pre-op</td>
<td>34.3</td>
<td>35.4</td>
<td>-</td>
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<tr>
<td>Post-op</td>
<td>85.9</td>
<td>89.1</td>
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<tr>
<td>Functional Knee Society score</td>
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<td></td>
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<tr>
<td>Pre-op</td>
<td>48.0</td>
<td>50.0</td>
<td>-</td>
</tr>
<tr>
<td>Post-op</td>
<td>89.6</td>
<td>92.4</td>
<td>0.44</td>
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<tr>
<td>Revised Oxford Knee score</td>
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<tr>
<td>Pre-op</td>
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<td>-</td>
</tr>
<tr>
<td>Post-op</td>
<td>36.5</td>
<td>40.6</td>
<td>0.12</td>
</tr>
</tbody>
</table>
DISCUSSION

The primary goal of TKA is restoration of mechanical axis and soft-tissue balance. Improper restoration may lead to poor functional outcome and premature prosthesis loosening and subsequent failure. Computer navigation enables precise femoral and tibial cuts and controlled soft-tissue release. Mechanical alignment and soft-tissue balance is closely interlinked and can be corrected by soft-tissue releases and by altering the proximal tibial and distal femoral cuts. The 2 common techniques used are measured resection and gap balancing techniques. In our study, knee scores of the 2 groups at the 2-year follow-up were compared, as most of the improvement occurs within one year, with very little subsequent improvement.

Some surgeons favour gap balancing technique, as it provides more consistent soft-tissue tension in TKA. The measured resection technique can be inaccurate lead to improper alignment of femoral component, because of wide variation in the anatomy of bony landmarks (epicondyles, the anteroposterior line, and posterior condyles) when making the femoral cuts. Others consider measured resection as an outdated technique in knee arthroplasty. Nonetheless, a combination of these bony landmarks helps to minimise the error of component malposition owing to anatomic variation. The navigation software in the Galileo system registers the transepicondylar axis, the Whiteside line, and posterior condyle lines to minimise errors.

Gap balancing technique also has limitations. First, it primarily relies on the horizontal cut of the upper tibial surface perpendicular to the mechanical axis. If the tibia is cut in varus and valgus, it will lead to internal and external rotation of the femoral component, respectively. Second, it relies on the integrity of both medial and lateral soft tissues. If there is medial of lateral ligament deficiency, there will be inappropriate tension of ligament in flexion and this will lead to internal and external rotation of the femoral component, respectively. Third, ligament tensioning is surgeon subjective, which may lead to inconsistency and thus femoral component malrotation. In our study, the upper tibial cut was made using computer navigation. Force feedback ligament tensioner was then used to give real-time feedback about how much pressure was applied while tensioning ligaments in flexion prior to the femoral cut. A constant pressure of 80 N was applied. Consistent tensioning of ligaments minimised variability between cases. Some studies have shown superiority of gap balancing technique over measured resection technique in achieving better coronal stability in TKA. Moreover, there is concern about surgeon’s inability to correctly identify bony landmarks for measured resection.

Our study was limited by the small number of patients. Moreover, only the knee scores were evaluated; other clinical parameters were not evaluated. Nonetheless, our study was prospective, blinded, and randomised. Functional scores were assessed by a single orthopaedic registrar blinded to the type of surgery. Improvement in the knee scores at 2 years was comparable after computer-assisted TKA using the measured resection versus gap balancing techniques.

REFERENCES