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Optimizing Posterior Condylar Offset and Joint Line Restoration in Revision Total Knee Arthroplasty Using a Contemporary Implant System

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Summary: We present a variation of the standard operative technique for the Triathlon total stabilized revision knee system that aims to facilitate recreation of an anatomic joint line, and increase the posterior condylar offset through flexion and posterior translation of the femoral component using short cemented intramedullary stems. We illustrate the technique with a sequential single-surgeon series of 29 patients undergoing total stabilized revision total knee arthroplasty. Joint line ratio is maintained and posterior condylar offset ratio increased from preoperative to postoperatively. Patient reported outcome scores (Oxford Knee Score) significantly improved by 15.6 points at 12 months ($P < 0.001$) with an overall positive satisfaction outcome of 88%.

Key Words: revision knee arthroplasty—patient reported outcome measures—revision knee replacement—joint line—posterior condylar offset.

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A longer life expectancy and increasing number of primary knee replacements has resulted in an expected increase in revision total knee arthroplasty (rTKA).[1–3] Results of rTKA are commonly thought to be inferior to primary knee replacement.[4–6] As such, techniques to facilitate successful patient outcomes in rTKA are of increasing relevance and importance.

The aims of rTKA are similar to those of the primary procedure; recreate an anatomic joint line (JL), restore flexion, and extension stability, ensure correct alignment, reconstruct bony defects and achieve stable implant fixation with appropriate constraint.

Our unit has previously reported high levels of physical function in patients undergoing rTKA with semiconstrained total stabilizer implants.[7] We demonstrated substantial improvements in the initial 2 years after surgery in patient reported outcome scores, pain scores, knee flexion, and timed functional performance in a prospective longitudinal patient cohort.[8] The surgical technique we promote emphasizes the restoration of JL and enhancement of posterior condylar offset (PCO) which is achieved through the use of short cemented diaphyseal stems.

Failure to restore the JL in revision TKA has been demonstrated to result in a diminished functional outcome.[9,10] JL elevation adversely affects range of motion,[11] stability,[12] and Knee Society Scores.[9,10,13] It is acknowledged that restoration of an adequate PCO in rTKA is important—providing stability in flexion and limiting posterior tibiofemoral impingement in deep flexion.[7,14,15] Improvement in postoperative outcome scores with increased PCO in rTKA has been reported previously[7,16] and found to be an independent predictor of clinical outcome.[7] Use of short cemented stems allows restoration of PCO in the revision setting without the need to oversize the femoral component and negates issues of stem tip pain at the anterior cortex that can result from long intramedullary (IM) stems and compromised anatomy.[7] Short cemented stems have been shown to provide excellent implant stability[17,18] while maintaining 2 zones of fixation (Fig.1).[19]

In this paper we present the variation of the standard surgical technique for the triathlon total stabilized (TS) revision system that has been developed and utilized at Edinburgh Royal Infirmary. We contextualize our focus on JL restoration and PCO through evaluation of a sequential single-surgeon series of semiconstrained Triathlon TS rTKA procedures performed at out institution with this surgical philosophy.

SURGICAL TECHNIQUE

A medial para patellar approach is used to perform an intracapsular synovectomy taking care to preserve the collateral ligaments. A medial release to the mid tibial point followed by PCL sacrifice if present allows patella slide. The in situ polyethylene insert is removed. After confirmation of an adequate lateral gutter clearance the patella is carefully everted. Occasionally, a lateral patella facetectomy is undertaken to assist patella eversion.

The medial epidcondylar pin is placed in the palpable sulcus of the medial epicondyle, and the current JL distance measured along with the femoral medial to lateral width. The implant interface is exposed and implants are removed with great care to ensure minimal bone loss. It is important to clear all sclerotic bone and cement from templated IM entry points to prevent reamer deflection. Significant cavitatory or uncontained defects may affect short stem fixation, either longer cemented stems with grafting, or more recently, cones can be utilized to give additional support.

The IM canal of the tibia is sequentially reamed to a minimum depth of 175 mm ensuring solid cortical engagement. A 0-degree posterior tibial slope cut is then made which is maximally

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The authors declare that they have nothing to disclose.

For reprint requests, or additional information and guidance on the techniques described in the article, please contact Anthony J. Samson, FRACS, FAOrthoA, at antsamson@gmail.com or by mail at Flinders University, Flinders Drive, Bedford Park, SA 5042, Australia. You may inquire whether the author(s) will agree to phone conferences and/or visits regarding these techniques.

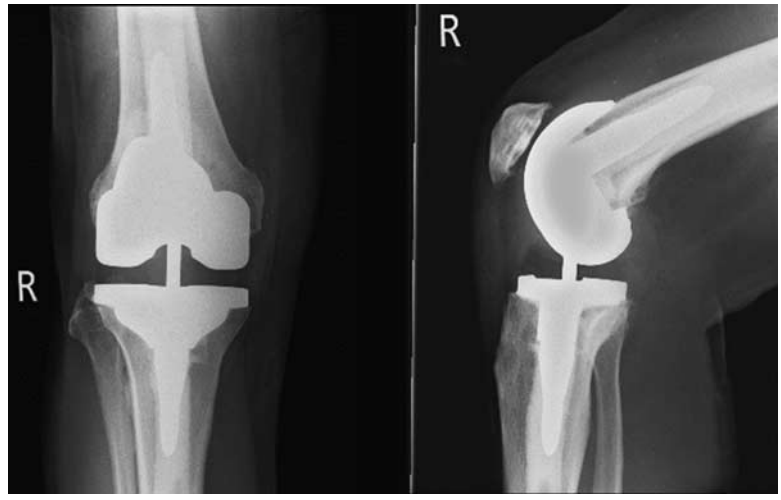

FIGURE 1. Revision total knee arthroplasty with zonal fixation utilizing short cemented stems.

bone preserving, and in our experience removes mainly anterior tibial cortex. An appropriate sized tibial preparation base plate with maximal coverage and within a single size of the templated femur is pinned with rotation checked. The remainder tibial preparation is undertaken with a keel cutter and boss ream. The definitive 9 mm×50 mm stem (no trial 9 mm×50 mm stem exist) is attached to the trial base plate and inserted.

Attention is now taken towards the femur with sequential IM reaming to ensure stability and anterior bow engagement at a depth of 120 to 150 mm. A more proximal isthmus engagement results in anterior translation of the IM rod, a relative extended implant position and hence the need for offsetting to maintain PCO. By avoiding proximal engagement and anterior translation with a flexed femoral component, the PCO is maintained without the need for offset adapters. The correct sided 6-degree valgus distal femoral cutting block is applied and an angel wing is passed through the "ME" slot. A cut through 0/5/10/15 mm slots with relevant augment will return the ME distance back to 28 mm. The block can be moved proximal or distal to the epicondylar pin to alter the JL to the operative plan. Following the distal cut, the appropriate sized augments are placed on the correct sized femoral finishing block locked at the 12 o'clock position, no offsetting (Fig. 2). This block is critical to femoral preparation as it determines rotation, medial-lateral translation and anterior-posterior translation. Existing anatomic landmarks are used to guide the block position (Box 1).

The block is pinned and following the anterior chamfer cut the additional magnetic block is added for stability. Following all the cuts, the boss reamer jig with added distal femoral augments is pinned once flush with the femur and reamed with the 19 mm boss reamer to the first etched line. A trial femur is then placed with a trial 12 mm×50 mm stem. A suitable sized cruciate retaining tibial insert is placed and trialled. Particular attention is placed on range of motion, patella tracking, coronal, and sagittal stability. The flexion gap is assessed at 90 degree of flexion with femoral-tibial distraction and anterior-posterior translation. This should be minimal ($\leq$2 mm). The JL distance in extension can be confirmed with a ruler. Using the described technique, it is seldom required to adjust for gap imbalance once the ME JL distance has been restored along with adequate PCO. Our common finding on trialling with a cruciate retaining insert is that we obtain a range of motion, balance and patellar tracking similar to a primary knee. If a flexion/extension gap mismatch is identified, this is managed with standard balancing techniques. Increasing femoral component size can tighten an isolated lax flexion gap, while more distal femoral augment for isolated extension gap laxity. A larger tibial insert is used for a symmetrical flexion extension gap.

The knee is thoroughly lavaged and an appropriate dose of 0.2% bupivacaine is injected about the knee. Canal sounds are used to measure cement plugs that are placed 1 cm distal to the femoral and tibial stems. Using 2 separate vacuum mixes of cement in a gun, the tibia followed by femur are sequentially placed, paying attention to maintain the slightly flexed femoral

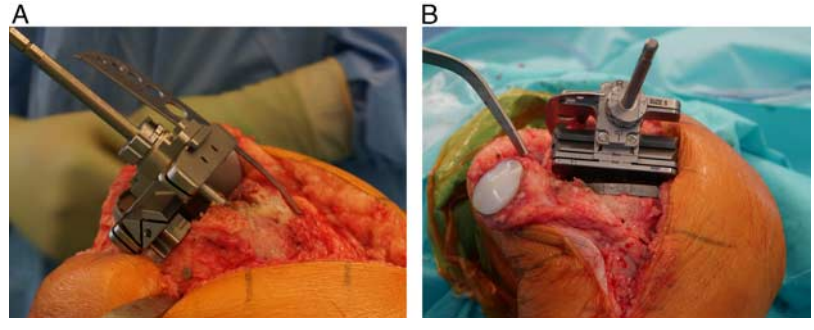

FIGURE 2. Revision total knee arthroplasty with zonal fixation utilizing short cemented stems. A, Femoral cutting block with distal augments. B, Femoral cutting block locked at 12 o'clock position confirming no offsetting.

BOX 1. Femoral Block Positioning

(1) Rotation is set from the epicondylar axis and is assisted by being parallel to the tibia at 90 degrees of flexion.
(2) Medial-lateral translation is set by the etchings on the cutting block to ensure no medial or lateral overhang, with a bias towards lateral translation to aide patella tracking.
(3) Anterior-posterior translation is gauged by the 7-degree anterior cut on the distal femur. An angel wing is placed in the lateral anterior chamfer cut to ensure no notching while also assisting with rotational assessment.

position on insertion. Excess cement is removed and the definitive TS insert placed. A 1 g vial of powdered vancomycin is placed intra-articularly followed by a layered closure with a combination of interrupted and interlocking continuous sutures.

MATERIALS AND METHODS

Prospective data were collected for consecutive single-surgeon series of rTKA performed by the senior author over a 4-year period (2011 to 2015). All procedures were rTKA to Triathlon TS implant (Stryker) using the previously described operative technique.

Reason for revision was evaluated from the patient notes, in the case of multiple modes of failure a primary indication was decided upon for reporting.

Preoperative and postoperative AP and lateral radiographs were reviewed to evaluate JL and PCO ratio. Coronal alignment was evaluated from full length lower limb radiographs. Limb alignment was measured as described by Luo.[20] JL was measured relative to the tibial tuberosity, as described by Figgie et al.[21] PCO was measured on a true lateral radiograph according to the technique described by Bellemans et al[14] and was corrected for radiographic magnification using the femoral diameter at the level of the posterior flare to calculate a ratio.[22,23]

Radiographs were independently reviewed by 3 orthopedic surgeons. Images were evaluated on 2 separate occasions and in a different order. Overall mean figures are reported. Agreement between reviewers was excellent (> 0.9 Kappa and interclass correlation coefficient).

Patient functional outcomes are reported preoperatively and at 12 months postoperatively with the Oxford Knee Score (OKS). This score consists of 12 questions which assess the patient's pain and function. Each item is answered on a 5-point response scale ranging from 0 to 4, and generates a summed total score ranging from 0 to 48, where 0 indicates the worst possible outcome and 48 good joint function. Satisfaction with outcome at 12 months is reported using a 5-point Likert scale (with possible responses ranging from very satisfied, satisfied, neither satisfied nor dissatisfied, dissatisfied, and very dissatisfied).

Data are presented as means with SD as a measure of dispersion. Preoperative to postoperative difference in assessed parameters were evaluated with paired samples t tests. Significance was accepted at $P = 0.05$.

TABLE 1. Mode of Failure as Documented for Reason of Revision

Diagnosis	N (%)
Instability	5 (17)
Aseptic loosening/osteolysis	20 (69)
Infection	2 (7)
Arthrofibrosis	1 (3.5)
Malalignment	1 (3.5)

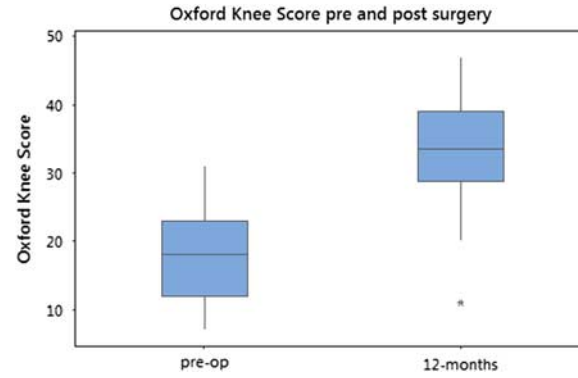

FIGURE 3. Difference in preoperative and 12 months postoperative Oxford Knee Scores.

RESULTS

In total, 29 patients with an average age of 72.9 (SD, 9.87; range, 53 to 89) were identified, 58% were male, mean body mass index was 30.6 (SD, 6.86; range, 22 to 48.5). Revision was primarily for a diagnosis if aseptic loosening (69% cases) and instability (17% cases), Table 1.

JL ratio was measured at 2.22 (SD, 0.27) preoperatively, and 2.28 (SD, 0.31) postoperatively, reflecting a delta change preoperative to postoperative of 0.06 (SD, 0.24). This difference was significant at $P = 0.001$ (paired samples t test). PCO ratio was measured at 0.88 (SD, 0.12) preoperatively, and 1.03 (SD, 0.15) postoperatively, reflecting a delta change of 0.15 (0.14). This difference was significant at $P < 0.001$ (paired samples t test).

Postoperative coronal alignment was measured at 178.17 (range, 173.52 to 184.03; SD, 2.95). Median insert thickness was 11 mm (interquartile range, 9 to 14.5 mm).

Patient functional outcomes (OKS) improved from a mean 17.8 points (SD, 6.82; range, 7 to 31 points) preoperatively to 33.4 points (SD, 8.98; range, 11 to 47 points) at 12 months postoperatively, reflecting a change score of 15.6 points (SD, 8.77; range, 8 to 29 points) (Fig. 3). This difference was significant at $P < 0.001$ (paired samples t test). Overall positive satisfaction outcome was 88% (Fig. 4). Two knees had superficial wound infections treated by community antibiotics, and 1 patient suffered a nonfatal pulmonary embolus.

DISCUSSION

We present the philosophy and variation of the standard surgical technique for the Triathlon TS system that we use at

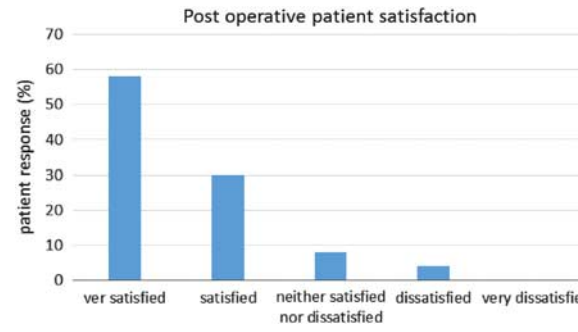

FIGURE 4. Patient satisfaction at 12 months postoperation.

our institution which focuses on maintenance of JL restoration and PCO that we believe promotes enhanced patient function.

The technique of short cemented stems allows femoral flexion and posterior translation thereby increasing the PCO while maintaining JL. The short cemented stems in the tibia allow offsetting to gain maximum coverage.

We present new data which demonstrates a significant improvement in Oxford Knee Score and very high post-operative patient satisfaction scores at 1 year. These findings echo those of previous reports[7,8] and support the notion that maintenance of JL and increasing PCO in revision arthroplasty is associated with improved outcomes.[8]

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