Lateral Unicompartmental Knee Arthroplasty Utilizing a Modified Surgical Technique and Specifically Adapted Fixed-Bearing Implant

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ABSTRACT

Background: Treatment of isolated lateral compartment arthritic disease with partial knee arthroplasty remains underutilized in comparison to medial unicompartmental arthroplasty. This study examines the survival and outcome of lateral unicompartmental arthroplasty utilizing the first implant specifically
Despite being relatively less common than anteromedial osteoarthritis, isolated lateral femorotibial osteoarthritis may still be experienced by 5% to 10% of those patients presenting with unicompartmental osteoarthritis of the knee. Surgical treatment options for those patients failing conservative modalities include varus-producing osteotomies, total knee arthroplasty, or unicompartmental knee arthroplasty. Extra-articular femoral or tibial osteotomy enables correction of valgus deformity and realignment of compressive forces in the knee and is typically indicated in younger patients with an active lifestyle. This treatment has shown less promise in cases of large intra-articular deformity or complete loss of cartilage in the lateral compartment, and presence of previous skin incisions and hardware complicate potential future total knee arthroplasty in these patients.

Shortcomings of osteotomy have made arthroplasty a significantly more utilized treatment option in this patient population. Total knee arthroplasty remains the most common arthroplasty treatment choice in this scenario, with some joint registry data suggesting that at least 20% of patients undergoing TKA may have isolated unicompartmental osteoarthritis disease. Despite this trend, the advantages of unicompartmental arthroplasty that have been reported after medial compartment procedures, including reduced morbidity, quicker recovery, preservation of bone stock, and more physiological knee function, have made the prospect of lateral unicompartmental arthroplasty more appealing.

Lateral unicompartmental arthroplasty, however, has been underutilized in comparison to medial unicompartmental arthroplasty in patients who meet indications for this treatment. These treatment differences are likely due to the technical challenge of performing lateral unicompartmental arthroplasty stemming from a lower number of indicated patients as well as the more complex functional anatomy of the lateral compartment. These challenges resulted in lower implant survivorship and clinical outcomes of
lateral unicompartmental implants observed in early studies.1,12–14 Improvements in patient indications, surgical techniques, and component designs have ameliorated problems seen in earlier studies. Refined indications include patients with a correctable valgus deformity and intact full-thickness medial compartment cartilage, an intact anterior cruciate ligament, ability to achieve full extension with a minimum of 100° arc of motion, and an unaffected patellofemoral joint on clinical and radiographic exam.15 Patients suffering from rheumatoid arthritis are contraindicated for this procedure. Moreover, increased dislocation risk seen with early mobile-bearing designs has brought about a tendency toward the use of fixed-bearing implants in these patients.12 Understanding issues with overcorrection of deformity in unicompartmental arthroplasty, as well as the unique kinematics of the lateral compartment, particularly the “screw-home” mechanism, has also dictated changes in overall component alignment and position.16,17 These advancements have improved patient outcomes and implant survivorship in recent studies; however, most of the past research has been performed in small patient cohorts with short-term follow-up. We have previously reported on a series of 100 consecutively lateral unicompartmental arthroplasties from 2004 to 2008 performed using a lateral parapatellar approach with a fixed-bearing cemented tibial component designed for the medial compartment (Vanguard M™ Partial Knee; Zimmer Biomet, Warsaw, Indiana).18 At a mean follow-up of three years, one patient had undergone conversion to total knee arthroplasty as contraindications for the surgical procedure. The purpose of our current study was to apply a new surgical technique and a modified fixed-bearing implant for lateral unicompartmental arthroplasty addressing aspects specific to lateral compartment kinematics and to determine the consequent patient outcomes and implant survivorship.

**MATERIALS AND METHODS**

A retrospective review identified 58 consecutive lateral unicompartmental arthroplasties in 54 patients occurring between January 2013 and May 2016. All patients signed a general research consent approved by an independent institutional review board (Western IRB, Puyallup, Washington) which allowed for retrospective review. The operations were all performed by a single surgeon experienced in unicompartmental arthroplasty. Patients were indicated for the procedure if they met specific clinical and radiographic criteria. After failing conservative measures for treatment of osteoarthritis, radiographs were examined to confirm the appropriate disease pattern. Anteroposterior weightbearing and 45° flexion posteroanterior views demonstrated signs of osteoarthritis or posttraumatic arthritis isolated to the lateral compartment. The lateral view demonstrated wear of the mid to anterior portion of the lateral tibial plateau and a maintained posterior tibial convexity. Absence of anterior tibial translation was noted to confirm an intact anterior cruciate ligament. A skyline view of the patellofemoral joint at 45° of flexion was required to show appropriate alignment of the patella within the trochlear groove and retained joint space independent of patella osteophyte formation. Varus stress radiographs were performed on all patients in the supine position to verify a correctible intra-articular deformity without ligament contracture and to confirm preservation of the medial joint space. The procedure was contraindicated if there was concern for medial compartment or patellofemoral joint space disease or if the deformity was fixed as assessed on the appropriate radiographic views. Patient demographics or activity level were not used as contraindications for the surgical procedure.

In the current study, the lateral unicompartmental arthroplasty system consisted of a spherical twin peg femoral component and a monoblock fixed lateral component with a flat articulation, both of which were fixed with cement (Oxford® Fixed Lateral Partial Knee, Zimmer Biomet, Warsaw, Indiana). The femoral component is identical to that of the mobile-bearing Oxford® Partial Knee as was the Oxford Microplasty® (Zimmer Biomet, Warsaw, Indiana) instrumentation used to perform the procedure. The tibial component is a metal-backed non-modular component with direct compression molded ultra-high molecular weight polyethylene (Architectural Computer Services, LLC; Salt Lake City, Utah) and a single keel baseplate. The tibial component was designed with the aid of multiple patient computed tomography (CT) scans to optimize coverage of the lateral compartment (Fox D., unpublished report, 2012, data on file with manufacturer). Using the Oxford® Microplasty® instrumentation, an adaptor is used for the distal femoral drill guide to flex the femoral component 5° and align the distal femoral resection neutral to the mechanical axis. Also, the spherical mills have a low profile that is different from those used in the medial compartment so that they may be inserted more easily into the lateral compartment irrespective of the approach utilized for the procedure.

Patients were positioned supine on a standard operating table. A standard midline incision was utilized and extended from a couple centimeters proximal to the superior pole of the patella and distally just medial to tibial tubercle. Via this skin incision, a lateral parapatellar arthrotomy was performed with careful dissection of the superficial peritenon and preservation of the infrapatellar fat pad to provide an extra vascularized layer for closure. A special patellar retractor was inserted to displace the patella medially throughout the procedure. After exposing the lateral tibial plateau and removing osteophytes from the intercondylar notch, sizing spoons were used to measure the femoral condyle radius of curvature. However, these spoons cannot be used as a stylus for the medial Oxford® Partial Knee, and instead, the tibial resection was made by the surgeon visually accounting for the amount of wear and disease within the lateral tibial plateau to accommodate a 4mm tibial implant. Given that the majority of the disease in isolated lateral compartment arthritis is located on the femoral side, an initial tibial cut that is roughly 4mm or less is recommended in most instances. Seven degrees of posterior tibial slope was established in the horizontal tibial resection while the vertical cut was made with a slight internal rotation and was flush with the lateral border of the tibial spine to maximize component coverage.
of the plateau as pictured in Figure 1. Following tibial resection, the initial extension gap is established to ensure full extension without recurvatum and, at most, 1 mm of varus or valgus laxity at approximately 10° of flexion as shown in Figure 2. The method used for balancing the lateral compartment was distinct from that of the medial unicompartmental procedure to recreate asymmetry between the flexion and extension gaps. Therefore, the focus is placed on initially balancing the extension gap throughout the procedure with the understanding that the flexion gap should demonstrate a couple millimeters of additional laxity. If this initial extension gap is excessively tight then more tibial bone may be removed at this time. Femoral preparation is then started using an intramedullary femoral alignment guide that sets the angulation of the distal femoral cut neutral to the femoral mechanical axis and the posterior femoral cut at 5° of flexion. The posterior condylar resection of bone and cartilage is equivalent to the thickness of the femoral implant which is 5 mm. The distal femoral reamer is used to create a spherical distal femoral shape, and the desired thickness is resected to match the initial extension gap. The gaps are reassessed at this time to ensure a stable extension gap and a flexion gap that demonstrates an additional 2 mm of laxity in comparison. The tibia is then prepared to accept the keel of the tibial implant. During examination with the trial implants, there should be perfect contact of the tibial and femoral components throughout the “screw-home” mechanism of the tibia, which is enabled by appropriate component rotation and position. Anatomic roll back of the femur in deep flexion is permitted by the tibial implant design. Finally, the anti-impingement guide is used to remove posterior femoral osteophytes that may cause impingement in flexion, but anterior femoral bone is not removed as in the medial unicompartmental procedure because this anterolateral condylar bone is crucial to patellar tracking. Femoral and tibial implants were secured with bone cement as demonstrated in Figure 3.

In three cases, a lateral unicompartmental arthroplasty was added to a knee that had already been treated with a medial unicompartmental arthroplasty. In this situation, the procedure was performed through the previous medial parapatellar arthrotomy to reduce the theoretical risk of avascular necrosis of the patella from a lateral arthrotomy. A Hohman retractor was used to retract the patella laterally throughout the surgery; however, the remaining technique was performed as described above.

All lateral unicompartmental arthroplasties were performed on an outpatient basis. Postoperatively, early mobilization was encouraged, and ambulatory assistive devices were gradually weaned. Patients were required to complete a structured outpatient physical therapy program three days per week for up to six weeks. There was no formal limit placed on the activity level of the patient and they were urged to perform activities with which they were comfortable.
Patients were evaluated at six weeks postoperatively and annually thereafter. At each visit, standardized clinical assessments were performed on all patients, which included components of the Knee Society clinical rating system, knee range of motion, and the University of California at Los Angeles (UCLA) activity scale. Patients who had not been evaluated in the most recent six months were contacted via telephone interview to determine the status of their implant and to administer the Knee Society pain and function rating scales.

RESULTS

One patient died, and one patient was lost to contact prior to returning for the minimum two-year follow up. Therefore, there were 56 lateral unicompartamental arthroplasties in 52 patients available for study with minimum two-year follow up (mean, 2.9 years; range, 2–5.5 years). There were 13 male and 39 female patients. Mean patient age was 64 years (range, 38–87 years) and mean body mass index was 29.6 kg/m² (range, 21–43 kg/m²). The primary diagnosis was osteoarthritis in 52 knees, avascular necrosis in one case, and three cases of lateral osteoarthritic progression following medial unicompartmental knee arthroplasty (UKA) (Table I).

At latest follow up, the mean Knee Society clinical score improved from 54 (range, 20–95) preoperatively to 94 (range, 62–100) postoperatively, and the functional score improved from 57 (range, 20–100) preoperatively to 78 (range, 40–100) postoperatively (Table II). Knee Society pain component improved from 10 (range, 0–50) preoperatively to 46 (range, 10–50) postoperatively. University of California Los Angeles activity scale increased slightly from a mean of 5.2 preoperatively to a mean of 5.7 postoperatively. Postoperative average ROM was relatively unchanged from a mean of 119° (range, 100–135) preoperatively to a mean of 121° (range, 95–135) at most recent clinical examination.

There were two reoperations following the primary lateral unicompartamental arthroplasty procedure, but none were performed for revision of the implant. There was one knee in which a medial unicompartamental arthroplasty was added 1.1 years after lateral unicompartamental arthroplasty due to arthritic progression in the medial compartment. The only other subsequent surgery was an irrigation and debridement at 43 days postoperatively performed in a patient with poor wound healing. No modifications were made to the implant and the patient’s postoperative course was uneventful. Two different patients required readmission within 90 days because of gastrointestinal issues.

DISCUSSION

When utilizing a new unicompartamental implant specific for the lateral compartment with a modified surgical technique, we encountered no implant revisions in a series of 56 lateral unicompartamental arthroplasties with an average patient age of 64 years at a mean follow up of 2.9 years. Substantial improvement in Knee Society clinical and functional scores were observed in the patient cohort with differences of 41 and 21, respectively, from pre- to postoperative scores. There were two reoperations which included one case of medial compartment osteoarthritic progression, in which a medial unicompartamental arthroplasty was performed, and another case of poor superficial wound healing in which an irrigation and debridement procedure was needed.

Previous surgical options for isolated lateral femorotibial osteoarthritis included extra-articular femoral or tibial

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<th>Characteristic</th>
<th>Mean (Range) or Frequency</th>
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<tr>
<td>Follow up (years)</td>
<td>2.9 (2–5.5)</td>
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<tr>
<td>Age (years)</td>
<td>2.9 (2–5.5)</td>
</tr>
<tr>
<td>Gender</td>
<td>39 (75%) females, 13 (25%) males</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>29.6 (21–43)</td>
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<tr>
<td>Diagnosis</td>
<td>52 (93%) osteoarthritis 1 (2%) avascular necrosis 3 (5%) lateral osteoarthritic progression following medial unicompartamental arthroplasty</td>
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(Ranges or percentages listed in parenthesis.)
ostectomy, which enables correction of the valgus deformity to target the compressive forces through the unaffected medial femorotibial compartment. The aim of this method is to slow or prevent the progression of the articular disease in the lateral compartment while enabling an active lifestyle in younger patients. Options consist of both medial closing wedge osteotomy of the femur or tibia or a lateral distal femoral opening wedge osteotomy. Clinical outcomes demonstrate satisfactory pain relief and restoration of function in some studies utilizing this method.22 However, certain limitations of this procedure and functional results have been recognized in patients with Ahlbäck grade 2 or greater osteoarthritis and with greater than 10° valgus deformity undergoing a medial closing wedge osteotomy of the femur or tibia.1,6,7,24 Thus, in cases of large intra-articular valgus deformity or complete loss of cartilage in the lateral compartment, arthroplasty may present the only viable option. Furthermore, presence of previous skin incisions and hardware complications are noted as total knee arthroplasty procedures in patients after femoral osteotomy resulting in less optimal functional results.6

Total knee arthroplasty remains the most common arthroplasty treatment choice for a patient in this scenario, with some joint registry data suggesting that at least 20% of patients undergoing TKA may have isolated unicompartmental disease amenable to treatment with either total knee arthroplasty or unicompartmental knee arthroplasty.7,8,25 Despite this fact, the advantages of unicompartmental arthroplasty that have been reported after medial compartment procedures, including reduced morbidity, quicker recovery, preservation of bone stock, and more physiological knee function, have made the prospect of lateral unicompartmental arthroplasty more appealing.9,11,26 Particularly, preserving medial bone stock simplifies potential future surgical procedures in the event that a total knee arthroplasty is needed.27,28

However, lateral unicompartmental arthroplasty is a technically challenging operation and, therefore, it has been estimated that medial unicompartmental arthroplasty is 10 times more likely to be performed than lateral arthroplasty in scenarios suitable for unicompartmental arthroplasty.1 Differences in anatomy of the medial and lateral compartments require a different method of treatment for this procedure. The amount of relative posterior translation of the lateral femoral condyle during flexion is believed to explain the historically poor functioning of a mobile-bearing unicompartmental arthroplasty.29,30 Gunther et al. first reported on 53 lateral unicompartmental arthroplasties using a mobile-bearing design with a 10% incidence of dislocation at a mean follow-up of five years.12 However, adjustments to the mobile-bearing design to maintain a full congruous spherical femoral articulation with a biconcave tibial plateau when the knee is brought from extension to 30° flexion.14 Placement should also accommodate the divergence of the lateral femoral condyle when the knee is flexed and to avoid impingement with the tibial spine in extension.15 Similarly, the tibial component should be rotated internally 10° to 15° to allow for the “screw-home” mechanism occurring during knee flexion.17

Adherence to refined patient indications has also shown increasing benefit in outcomes following this procedure. Lateral unicompartmental arthroplasty may be considered a viable treatment in a patient suffering from symptomatic osteoarthritis, osteonecrosis, or post-traumatic arthritis limited to the lateral compartment of the knee, but it is contraindicated in those patients with inflammatory arthritis.13 These patients otherwise should meet similar criteria as those established for consideration of medial unicompartmental arthroplasty. These include a correctable deformity with application of varus stress radiography and demonstration of intact full-thickness medial compartment cartilage, an intact anterior or cruciate ligament, ability to achieve

<table>
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<th>Table II</th>
<th>Clinical outcomes following lateral unicompartmental arthroplasty</th>
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<td></td>
<td>Preoperative</td>
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<tr>
<td>Knee Society clinical score</td>
<td>54 (20–95)</td>
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<tr>
<td>Knee Society function score</td>
<td>57 (20–100)</td>
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<tr>
<td>University of California at Los Angeles activity scale</td>
<td>5.2 (2–9)</td>
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<tr>
<td>Range of motion (degrees)</td>
<td>119 (100–135)</td>
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(Ranges listed in parentheses.)
full extension with a minimum of 100° arc of motion, and an unaffected patellofemoral joint on clinical and radiographic exam. While earlier studies demonstrated mixed results, recent advancements in patient indications, surgical techniques, and component designs have led to improved outcomes. Marmor first reported his results utilizing a cemented all-polyethylene tibia with 11 excellent results in 14 arthroplasties. Sah and Scott reported functional improvement and no revision procedures in a series of 49 procedures at mean five-year follow up using a medial parapatellar approach and a cemented polyethylene tibial component. Argenson reported on 40 procedures using a cemented metal-backed component with fixed-bearing at mean 12-year follow up and demonstrated that 63% of patients returned to their preoperative level of activity with prosthesis survivorship of 92% at 10 years and 84% at 16 years. Four of the six revision procedures in this series were due to arthritic progression in another compartment and the authors emphasized the need for strict adherence to preoperative varus stress radiography and patellar skyline views to assess the degree of deformity correction and the integrity of the other compartments. Multiple recent reports with small patient cohorts have corroborated these results in 14 arthroplasties. Argenson reported on 40 procedures at mean five-year follow up using a medial parapatellar approach and a cemented polyethylene tibial component. Argenson reported on 40 procedures using a cemented metal-backed component with fixed-bearing at mean 12-year follow up and demonstrated that 63% of patients returned to their preoperative level of activity with prosthesis survivorship of 92% at 10 years and 84% at 16 years. Four of the six revision procedures in this series were due to arthritic progression in another compartment and the authors emphasized the need for strict adherence to preoperative varus stress radiography and patellar skyline views to assess the degree of deformity correction and the integrity of the other compartments. Multiple recent reports with small patient cohorts have corroborated these outcomes at midterm follow up. Likewise, we previously reported only three revision procedures in 100 consecutive procedures at mean three-year follow up implanting a fixed-bearing metal-backed tibial component through a lateral parapatellar arthroscopy. There are several limitations to our study that must be considered when interpreting our results. First, all operations were performed by one surgeon with a significant volume of experience in both medial and lateral unicompartmental arthroplasty. The results of this study do not reflect those of a surgeon in the learning curve of the operation, which may have affected the outcomes of this procedure. Given the technical challenge associated with unicompartmental arthroplasty in the literature, particularly in the medial compartment, these results may not be applicable to a surgeon at an earlier stage within their unicompartmental arthroplasty experience. Furthermore, one of the failure modes in our study was progression of arthritis in the medial compartment, which required conversion of a lateral unicompartmental arthroplasty to a primary total knee arthroplasty through the previous lateral parapatellar arthroscopy. Performing total knee arthroplasty through a lateral parapatellar arthroscopy may be difficult for some surgeons, necessitating the addition of a medial parapatellar arthroscopy with the increased risk of patellar avascular necrosis. Follow up at two years was incomplete in one presumed living patient (one knee) and another elderly patient who died, thus their revision status remains inconclusive. However, minimum two-year follow up was available for 96% of patients. Finally, the follow up was short term with a mean of 2.9 years; therefore, statistical survivorship analysis was not performed.

The purpose of our current study was to apply a new surgical technique and a modified fixed-bearing implant for lateral unicompartmental arthroplasty addressing aspects specific to lateral compartment kinematics and to determine the consequent patient outcomes and implant survivorship. Strict patient indications were applied during preoperative clinical evaluation. A new implant was utilized in all patients, which was specifically created to reflect the anatomy and kinematic profile of the lateral compartment. Lateral parapatellar arthroscopy and modified surgical instrumentation were used to perform the procedure with special attention to component alignment and positioning to permit the natural “screw-home” mechanism of the lateral compartment. Moreover, no activity restrictions were placed on our patient cohort with a mean age of 64 years. As a result, there was one case of medial compartment arthritic progression, and one subsequent irrigation and debridement, but no component revisions at a mean follow up of nearly three years. Knee Society clinical and functional scores improved by 41 and 21 points, respectively. Lateral unicompartmental arthroplasty is an effective surgical treatment for patients with isolated lateral compartment arthritic disease meeting specific indications. Surgeon familiarity with the procedure and long-term outcomes need to be investigated to further characterize expected outcomes following this surgery.

CONCLUSION

REFERENCES


Authors’ Disclosures

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