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Regional Femoral and Tibial Radiolucency in Cemented Unicompartmental Knee Arthroplasty and the Relationship to Functional Outcomes

Laura J. Kleeblad, MD [a, *], Jelle P. van der List, MD [a], Hendrik A. Zuiderbaan, MD, PhD [b], Andrew D. Pearle, MD [a]

[a] Department of Orthopaedic Surgery, Sports Medicine and Shoulder Service, Hospital for Special Surgery, Weill Medical College of Cornell University, New York, New York
[b] Department of Orthopaedic Surgery, Noordwest Hospital, Alkmaar, The Netherlands

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ABSTRACT

Background: Femoral and tibial radiolucent lines (RLL) after unicompartmental knee arthroplasty (UKA) can be categorized in physiological and pathological radiolucencies. Although physiological tibial radiolucency is assessed extensively in literature, studies reporting femoral radiolucency are lacking. Therefore, a retrospective study was performed to assess physiological femoral RLL and its relationship to short-term functional outcomes.

Methods: A total of 352 patients were included who underwent robotic-assisted medial UKA surgery and received a fixed-bearing metal-backed cemented medial UKA. Radiographic follow-up consisted of standard anteroposterior and lateral radiographs. Functional outcomes, using the Western Ontario and McMaster Universities Arthritis Index questionnaire, of patients with RLL were compared with a matched cohort, based on gender, age, and body mass index.

Results: In this cohort, 101 patients (28.8%) had physiological regional radiolucency around the femoral (10.3%) and/or tibial (25.3%) components, of which 6.8% concerned both components. Tibial RLL were more frequently seen compared with femoral RLL ($P < .001$). Our data suggest that the time of onset of femoral radiolucency develops later (1.36 years) than tibial radiolucency (1.00 years, $P = .02$). No difference in short-term functional outcomes was found between the RLL group and the matched cohort group without radiolucency.

Conclusion: This study acknowledges that tibial and femoral physiological radiolucencies may develop after cemented medial UKA. Furthermore, this was the first study showing that physiological femoral RLL occur later than tibial RLL. Prospective studies with longer follow-up and larger numbers are necessary to compare radiolucency in different UKA designs and the relationship to outcomes.

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Unicompartmental knee arthroplasty (UKA) is a common treatment option for isolated medial knee osteoarthritis (OA), with good to excellent results at 5- and 10-year follow-up [1–4]. Recently, a large systematic review showed survivorship of 94% after 5 years and 92% after 10 years [3]. Concerning the modes of failure after UKA surgery, several studies and national registries have noted that aseptic loosening is one of the most frequent causes of revision [5–10].

Importantly, periprosthetic radiolucent lines (RLL) after UKA can be divided into pathologic and physiologic types of radiolucencies [11]. As Goodfellow et al [11–13] described, pathological RLL are >2 mm, poorly defined, and often related to aseptic loosening. On the contrary, physiological RLL are 1-2 mm and well-defined. The presence of these RLL is neither related to symptoms nor indicative or predictive of loosening according to current literature [11,12,14]. The etiology of radiolucency remains unknown; although, association between postoperative leg alignment and the emergence of

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* Reprint requests: Laura J. Kleeblad, MD, Department of Orthopaedic Surgery, Sports Medicine and Shoulder Service, Hospital for Special Surgery, 535 East 70th St, New York, NY 10021.

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RLL has been suggested by several authors [11,15,16]. Many studies have reported on the incidence of physiological tibial RLL, ranging from 62%-96%, which were clinically not related to inferior functional outcomes [13,14,17,18]. However, only a few older studies have assessed RLL around the femoral component, when different UKA designs were used [2,19]. There are no recent studies which assess the different aspects of physiological femoral radiolucency around cemented medial UKA, especially relative to the frequency of tibial radiolucency.

Therefore, this study assessed the incidence of physiological femoral and tibial radiolucency in cemented UKA. Aims of this article were to evaluate the incidence of RLL of the femoral component in relationship to the tibial component in different alignment ranges. Furthermore, the time of onset of radiolucency and its correlation with short-term patient-reported functional outcomes was assessed. We hypothesized that physiological femoral RLL are commonly seen regionally around the femoral component, but are not correlated with inferior functional outcomes after UKA.

Materials and Methods

Study Design and Patient Selection

Our study was carried out at Hospital for Special Surgery, with a prospective database that included over 900 UKAs, which were performed over the last 8 years by the senior author (A.D.P.). After institutional review board's approval (IRB 2013-056), an electronic registry search was performed for all patients who underwent medial UKA between April 2008 and December 2015. The surgical indications were medial compartment OA, no significant joint space narrowing in the lateral compartment, an intact anterior cruciate ligament, a correctable varus deformity, and a fixed flexion deformity of <10°. Surgical contraindications included the presence of Kellgren-Lawrence grade III or greater OA of the lateral compartment, patellofemoral-related pain symptoms, or inflammatory arthritis. Obesity was not a contraindication, as several studies have shown that increasing body mass index (BMI) is not associated with increasing failure or worse outcomes [20–24]. Inclusion criteria for this study were: (1) medial onlay UKA, (2) baseline radiographs at 2 weeks postoperatively, and (3) available functional outcomes. Patients with bicompartmental arthroplasty or different types of UKA than the study implant were excluded.

Implant and Surgical Technique

All patients received the identical cemented fixed-bearing Medial Onlay implant (RESTORIS MCK, Stryker, Mahwah, NJ). All surgeries were carried out by the senior author (A.D.P.), using a robotic-arm assisted surgical platform (MAKO System, Stryker, Mahwah, NJ) [25,26]. The surgical goal was to establish a relative undercorrection of the preoperative varus alignment to avoid osteoarthritic progression on the lateral compartment [27,28].

Radiologic Assessment

Radiographic evaluation was performed in Picture Archiving and Communication System (PACS, Sectra Imtec AB, Version 16, Linköping, Sweden). The anteroposterior (AP) and lateral radiographs were obtained 2 weeks postoperatively, repeated after 6 weeks and during follow-up visits after surgery. In addition, hip-knee-ankle (HKA) radiographs were taken at 6-week follow-up to assess the postoperative leg alignment. All radiographs were taken according to a standardized protocol, consisting of AP weight-bearing view, lateral view at 30° of flexion and HKA standing radiograph, for which the x-ray beam was aligned with the patella and foot and centered at the distal pole of the patella, aligning the image parallel to the tibial joint line in the frontal plane [29]. The radiographic assessment for this study was performed by a single assessor (L.J.K.), according to current and validated standards in the literature [14,18,30]. The radiographic assessment was conducted blinded to clinical scores. Similar to previous studies assessing radiolucency, the AP radiograph was used to assess tibial RLL, dividing the area underneath the tibial tray into 5 zones (Fig. 1A) [14,17,18,31]. Femoral RLL were assessed using lateral radiographs, because the component-bone interface is not visible on the AP view. Therefore, the flat area at the anterior and posterior femoral condyle was examined on the lateral view, as well as the area around the 2 pegs of the implant (Fig. 1B) [17,31]. Radiolucency is quantified by physiological and pathological RLL. Physiological RLL are well-defined, 1-2 mm thick, accompanied with a radiodense line, in contrast to pathological RLL that are >2 mm thick, poorly defined, and have no radiodense line [11].

The time of onset of RLL on the radiographs was scored by screening every radiograph from direct postoperative until the most recent one; however, this was depending on the regularity of the follow-up visits. The time of onset was related to patient-reported outcomes to compare the 2 groups (RLL vs non-RLL). Furthermore, the postoperative leg alignment (HKA angle) was measured on HKA radiographs of all patients.

Functional Outcomes

Patient-reported functional outcome scores were collected using the Western Ontario and McMaster Universities Arthritis Index (WOMAC). The WOMAC is a validated questionnaire in the setting of knee OA and quantifies the patient-reported outcome using 24 Likert-scale questions [32,33]. Questionnaires were collected during clinic visits or electronically by email, preoperatively and at 1-, 2-, and 5-year follow-up. Functional outcomes of patients with RLL were compared with a matched cohort without any RLL, based on gender, age, and BMI. All patients with WOMAC scores after the occurrence of RLL were matched with a patient without radiolucency, based on gender, age (within range of 3 years), and BMI (within range of 3 kilograms per square meter).

Statistical Analysis

Analyses were carried out using Excel 2010 (Microsoft Corp, Redmond, WA) and SPSS version 24 (SPSS Inc, Armonk, NY). The clinical details including gender, age, BMI, date of surgery, date of radiographic follow-up, and frequency of femoral and tibial RLL were assessed using descriptive statistics, consisting of mean, range values, and frequencies reported as percentages. Chi-square test was used to assess the differences between the incidence of femoral and tibial RLL. Furthermore, an analysis of variance was conducted to test for any differences in clinical characteristic features among the 3 patient groups (femoral RLL, tibial RLL, and both component RLL). Finally, continuous outcomes were used to compare functional outcomes in RLL group and non-RLL group. Paired *t* tests were performed to compare both groups based on their WOMAC scores. Statistical significance was set at $P < .05$.

Results

Between April 2008 and December 2015, 964 medial UKA were performed, 613 patients were excluded for this study. The reasons for exclusion were missing baseline radiographs or usage of