THE POSTOPERATIVE RADIOLOGICAL EVALUATION OF THE OXFORD MICROPLASTY® UNICOMPARTMENTAL KNEE REPLACEMENT INSTRUMENTATION

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Abstract

Introduction. Recently, new model of Oxford mobile-bearing unicompartmental knee arthroplasty (UKA, Oxford Microplasty®, Zimmer Biomet, IN, USA) was launched to improve previous version (Oxford Phase 3, Biomet, IN, USA). Still, there are few reports demonstrating the results of this noble UKA prosthesis in the literature. Thus, the aim of this study is to report and assess the postoperative radiological outcomes of the Oxford Microplasty® instrument.

Materials and methods. From March 2013 to October 2013, twenty-one patients (23 knees) underwent mobile UKA for medial compartment osteoarthritis using this noble instrument. Postoperative radiological outcomes were measured for operated lower limb alignment and implant position, and they were compared with those of 64 UKAs using the Oxford Phase 3 which had been performed from January 2010 to August 2012. Pre-and post-operative deformity of the knee in the coronal plane, the location of the mechanical axis with respect to the center of the tibial surface, positioning of the tibial and femoral components and varus and valgus alignment for the tibial and femoral components were evaluated.

Results. In the Microplasty® patients, preoperative HKA angle was 172.8±2.5° and postoperative HKA angle increased to 177.7±2.8° (p<0.001). There were no significant differences in postoperative HKA angle between Oxford Phase 3 and Microplasty group (178.4° vs. 177.7°, p>0.05). There were no significant differences in postoperative limb alignment and component position between the Microplasty group and Oxford Phase 3 group except femoral component flexion (11.9±2.1° vs. 2.6±4.1°, p<0.001). In addition, there were not any outliers in measurements of the components in the Microplasty group.

Conclusion. UKA using Oxford Microplasty® includes noble tools including femoral sizing spoon, G-clamp, longer IM rod, two-peg femoral component, and IM link system to help with ease of use, precision, efficiency, and reproducibility. Increased flexion of femoral component and increased total arc of femoral component will be more suitable especially for Asian patients who perform more flexion such as squatting and sitting on the floor in daily living activities.

Key words: unicompartmental knee replacement, radiological evaluation.

Introduction

Unicompartmental knee arthroplasty (UKA) is a reliable surgical option to treat unicompartmental osteoarthritis in the knee joint [1, 2]. The survivorship and function of UKA have been gradually improved since its introduction more than thirty years ago as a result of improved materials, designs, patient selections, and surgical techniques [1, 3]. Many clinical studies have reported satisfactory results with survivor rates over 90% at mid- to long-term follow-up by both the designing group and many independent centers [4, 7].

The Oxford unicompartmental knee instrument (Oxford, Zimmer Biomet, IN, USA) is a fully congruent mobile-bearing implant. It has the potential advantage of allowing more confirmed sur-face and thus reducing contact stresses through larger contact areas [8]. The Phase 1 Oxford instrument was first introduced in 1978. Through the Phase 2 instrument, the Oxford Phase 3 UKA became available in 1998 [9]. Different from the Phase 1 and 2 implants, the Oxford Phase 3 allowed minimally invasive approach and a larger range of component sizes than previous versions. Many studies about the Oxford Phase 3 UKA demonstrated successful clinical results in Europe, Asia, and USA [4, 6, 9, 13].

In spite of these excellent clinical results, during the use Oxford Phase 3 instrument still has some limitation in the precise positioning of an implant, which may cause bearing dislocation, loosening of the tibial and femoral component, and variations in femoral component position [2, 14, 15]. Furthermore, some

studies have reported high rate of revision after the Oxford UKA in large academic practices and national registries [15]. To overcome these problems, noble version of the Oxford unicompartmental knee prosthesis (Oxford Microplasty®, Oxford, Zimmer Biomet, IN, USA) has been recently developed with newly designed femoral component and improved surgical instruments.

Still, there are few reports demonstrating the results of this noble UKA prosthesis in the literature. Thus, the aim of this study is to report and assess the postoperative radiological outcomes of the Oxford Microplasty® instrument.

Patients and Methods

Approval of the present study was obtained from the institutional review board of our medical center. Our study included the whole number of patients operated and analyzed by the authors only at the specified period. From March to October 2013, twenty-one patients (23 knees) underwent mobile UKA for medial compartment osteoarthritis using the Oxford Microplasty instrument by authors. Of the 21 patients, 18 were female and the other 3 were male. The mean age was 66.5 years (range, 55 to 85 years). Postoperative radiological outcomes were measured for operated lower limb alignment and implant position, and they were compared with those of 64 UKAs (6 male and 58 female; mean age 66.5 years with range from 41 to 85 years) using the Oxford Phase 3 which had been performed in the same center from January 2010 to August 2012. All prostheses were cemented.

Patient selection for the present study followed the criteria of A. Carr et al. [16]. These criteria consisted of patients with medial compartmental osteoarthritis, intact anterior and posterior cruciate ligaments, correctable varus deformity which was best visualized on varus and valgus stress radiographs, minimal or absent degenerative changes in the lateral knee compartment on standing simple radiographs, absence of tenderness in lateral compartment, and no more than minimal patella-femoral abnormalities on radiographic and clinical evaluations. Exclusion criteria for surgery were inflammatory arthritis such as rheumatoid arthritis, full-thickness cartilage loss of the patella, and prior high tibial osteotomy. Of the 23 knees, 21 were diagnosed as degenerative osteoarthritis and the other two were spontaneous osteonecrosis of the knee. The operations were performed by the same surgeons, the responsible professor Lim, Hong-Chul have more than thirty five year surgeon and twenty five years knee arthroplasty surgeon experiences.

Surgical Technique

With affected knee in flexion on the thigh support, a minimal medial parapatellar incision from the medial margin of the patella to a 3 cm distal to the joint line was made. In the lower part of the wound, the front of the tibia was exposed and as much of the medial meniscus as possible was removed without any release of medial collateral ligament. The ACL was inspected to ascertain that it is intact without definite degeneration or tear. Then, all osteophytes on medial margin of the medial femoral condyle and both margin of the intercondylar notch were removed.

After these preparations, the femoral sizing spoon was inserted starting with 1 mm thick to assess the proper ligament tension. By capturing the medial femoral condyle with this sizing spoon, restoration of joint space could be performed. The tibial saw guide was applied with its shaft parallel to long axis of tibia in both sagittal and coronal planes. Then proximal tibial coupling clamp (G-clamp, 3 & 4-mm options) was applied to connect the femoral sizing spoon and tibial saw guide (Fig. 1). The size of the G-clamp corresponds to the depth of tibial resection and the expected thickness of the polyethylene bearing. Then, after fixing the tibial saw guide in place, the clamp and spoon were removed and tibial resection was performed in the same manner with previous version.

Femoral canal was opened with a 4 mm drill and sequential 5 mm awl at 1 cm anterior to anteromedial corner of the intercondylar notch with the knee in about 45° flexion. After insertion of the intramedullary (IM) rod (5 mm x 300 mm) through the anatomical axis of the femur, a line was drawn down the center of the medial femoral condyle for later reference of femoral drill guide. Then the newly developed femoral drill guide was inserted at the center of the medial femoral condyle adjusting the guide position according to pre-drawn line on the medial femoral condyle. The Oxford IM Link was inserted into the IM rod and lateral hole of the femoral drill guide. This would ensure more correct alignment of the femoral drill guide with maintaining 10° flexion and 7° varus alignment of guide to IM rod. Then 4 and 6 mm holes were drilled and we checked the hole position on the medial femoral condyle (Fig. 2). The femoral posterior resection guide was inserted and cutting was performed (Fig. 3).

The milling of distal femoral condyle was performed using a spigot system in the same manner with previous version. Different from the Oxford Phase 3, we additionally trimmed the anterior and posterior condyle of the femur to reduce the risk of impingement of bone against the polyethylene bearing in full flexion and full extension. To prevent an-

terior impingement, anti-impingement guide application and anterior milling were performed (Fig. 4), and posterior osteophytes were removed using the osteophytes chisel leaving the anti-impingement guide in place.

Then after inserting trials and checking the laxity in 20° & 100°, all real components were inserted with cementing (Palacos cement, Stryker Orthopaedics, Mahwah, NJ).

Postoperatively, patients began routine physiotherapy and exercise. The weight-bearing was allowed as tolerated.

Radiological Assessment

A descriptive report of the postoperative radiographic outcomes was performed using means and standard deviations. Pre- and post-operative deformity of the knee in the coronal plane was evaluated with use of the hip-knee-ankle (HKA) angle from a 90 cm standing anteroposterior (AP) radiograph of the entire lower limb (Fig. 5–7). The location of the mechanical axis with respect to the center of the tibial surface was assessed using a classification described by W.R. Kennedy and R.P. White [17]. Positioning of the tibial and

Fig. 1. Assembly of the femoral sizing spoon and the tibial cutting guide using the coupling clamp (G-clamp). The femoral sizing spoon is located at the center of the medial femoral condyle. The tibial cutting guide is applied parallel to the long axis of the tibia. The size of the G-clamp (3 or 4 mm) corresponds to the depth of tibial resection

Fig. 2. Connecting the IM rod and the femoral drill guide using the IM link. This link makes consistent position of the femoral drill guide (10° flexion and 7° varus alignmentagainst the IM rod). After femoral hole drilling, we could find the correct hole position on the pre-drawn line (a vertical mid-line on the medial femoral condyle)

Fig. 3. Newly designed femoral posterior resection guide. Using this noble instrument,more precise resection of posterior femoral condyle could be achived

Fig. 4. Anterior milling to prevent anterior impingement. After milling of distal femoral condyle, anti-impingement guide was applied. Then additional milling of the anterior aspect of the medial femoral condyle was performed using the Oxford anterior bone mill

femoral components was assessed by the Oxford Partial Knee Surgical Technique operating manual [18]. Varus and valgus alignment for the tibial and femoral components was evaluated on the AP simple radiograph in relation to the tibial anatomical axis, and flexion/extension alignment was measured on a lateral radiograph relative to the posterior cortex of the tibia and femur. Radiograph measurement in the patients performed twice; postoperatively after two weeks and within interval from six month to two years.

Fig. 5. Postoperative radiographs of the Oxford Microplasty

Fig. 6. The femoral component has two pegs in the Microplasty instrument. More flexed position and increased arc of the femoral component are identified in the Microplasty instrument

Fig. 7. Postoperative radiographs of the Oxford Phase 3. Only one peg is visible on the femoral component

The tolerances which are specified in the Oxford operating manual are that the femoral component would be positioned within a range of ±10° varus/valgus in a coronal plane, 0° extension to 15° flexion in a sagittal plane, and posterior overhang below 4 mm and the tibial component would be implanted within a range of ±5° varus/valgus in a coronal plane, and 2° to 12° of posterior tilting in a sagittal plane (Fig. 8).
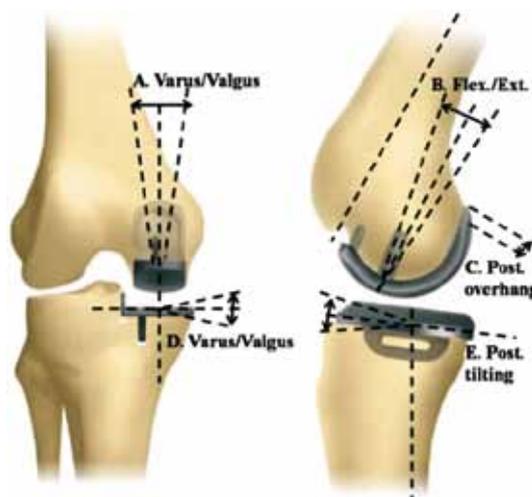

Fig. 8. Diagrams showing the postoperative radiological measurements described in the operating manual of the Oxford Microplasty unicompartment knee replacement

Statistical Analysis

The reliability of the measurement was evaluated by calculating the intra-class correlation coefficients (ICC). The measurements were considered reliable if the ICC was calculated more than 0.80. Normal distribution of the data was validated with use of the Kolmogorov-Smirnov test. Statistical analysis was performed in both groups. Both parametric and non-parametric tests were used with a consideration of statistical significance when $p<0.05$. Analysis was performed using SPSS software (Version 15.0, SPSS Inc., Chicago, IL, USA).

Results

In the Microplasty® patients, preoperative HKA angle was $172.8\pm2.5°$ and postoperative HKA angle increased to $177.7\pm2.8°$ ($p<0.001$). There were no significant differences in postoperative HKA angle between Oxford Phase 3 and Microplasty group (178.4° vs. 177.7°, $p>0.05$). Considering the alignment correct when the mechanical axises is in Zone 2 or C according to the Kennedy and White classification, most of knees showed correct postoperative alignment (zone 2 or C)

in both groups (87.0% in the Microplasty and 90.6% in the Oxford Phase 3, p>0.05). Femoral components were positioned in valgus 1.7±1.4° in the Microplasty group (2.3±2.4° in the Oxford Phase 3, p>0.05). Femoral component flexion in lateral radiographs were measured as flexion 11.9±2.1° in the Microplasty group and it was significantly higher than the Oxford Phase 3 group (2.6±4.1°, p<0.001).Posterior overhanging of femoral component was measured as 1.4±1.0 mm without significant differences compared with the Oxford Phase 3 group (1.4±1.4 mm, p>0.05). In tibial component assessment, tibial component coronal alignments were measured as varus 0.8±1.0° in the Microplasty group. They were more neutral than those in the Oxford Phase 3 group without significance (varus 1.3±2.2°, p>0.05). Posterior tibial slope did not show significant differences, either (5.9±1.4° in the Microplasty group vs. 5.8±2.2° in the Phase 3 group, p>0.05) (Table).

In short, femoral component flexion was significantly higher in the Microplasty group and there were no significant differences in any other measurements between the Oxford Microplasty group and the Oxford Phase 3 group. However, measurements of the components showed more neutral position in the Microplasty group. In all measurement, standard deviations were smaller in the Microplasty group, that is, the Microplasty group showed more narrow range of measurements. In addition, there were not any outliers in measurements in the Microplasty group.

Discussion

This study is the first report of the Oxford Microplasty® instrument to the best of our knowledge. Our results showed that the position of the femoral and tibial component in all 23 UKAs was within the limits of flexion/extension (0° extension to 15° flexion in the femoral component) and varus/valgus (±10° varus/valgus in the femoral component and ±5° varus/valgus in the tibial component). There were no outliers in all measurements, and the standard deviations of the Microplasty group were smaller than those of the Oxford Phase 3 group.

Several previous studies about the Oxford Phase 3 demonstrated that the position of the femoral component showed wide variations especially in the flexion/extension [2, 19, 21], N.P. Kort et al. pointed out the reason for this result was that the error in the sagittal alignment of the intramedullary (IM) rod might be larger than that in the coronal error. In addition, the authors demonstrated that the femoral drill guide was not fixed directly to the IM rod, inducing uncertain positioning

Table

Postoperative radiological outcomes in the Oxford Microplasty and the Oxford Phase 3 (SD, Standard Deviation; ICC, Intraclass Correlation Coefficient; CI, Confidence Interval)

Parameter	Oxford Microplasty		Oxford Phase 3		P-value
	Mean (SD range)	ICC (95% CI)	Mean (SD; range)	ICC (95% CI)	
Pre-operative Hip-Knee-Ankle angle	172.8 (2.5; 167.4 to 177.3)	0.927 (0.828 to 0.969)	173.6 (3.0; 167.1 to 178.0)	0.963 (0.940 to 0.978)	0.618
Post-operative Hip-Knee-Ankle angle	177.7 (2.8; 171.8 to 183.5)	0.922 (0.816 to 0.967)	178.4 (3.0; 173.5 to 184.5)	0.986 (0.977 to 0.992)	0.403
Femoral component varus(-)/valgus (+)	1.7 (1.4; -1.5 to 5.1)	0.976 (0.943 to 0.990)	2.3 (2.4; -3.2 to 8.5)	0.99 (0.984 to 0.994)	0.095
Femoral component flexion	11.9 (2.1; 7.4 to 14.9)	0.951 (0.884 to 0.979)	2.6 (4.1; -9.9 to 11.9)	0.983 (0.972 to 0.990)	<0.001
Femoral component posterior overhang	1.4 (1.0; 0.2 to 3.8)	0.965 (0.917 to 0.985)	1.4 (1.4; -1.9 to 4.0)	0.99 (0.983 to 0.994)	0.692
Tibial component varus(-)/valgus(+)	-0.8 (1.0; -2.6 to 1.5)	0.964 (0.916 to 0.985)	-1.3 (2.2; -7.0 to 3.1)	0.975 (0.960 to 0.985)	0.492
Tibial component posterior tilting	5.9 (1.4; 3.3 to 8.5)	0.926 (0.825 to 0.969)	5.8 (2.2; -1.6 to 9.6)	0.949 (0.916 to 0.969)	0.631

of the femoral drill guide, which resulted in uncertain positioning of the femoral component [22], J.G. Kim et al. also proposed to use a link between the IM rod and the femoral drill guide to make more reproducible position of the femoral component [2]. As the recommendations of previous authors, the IM linker system was introduced in the Oxford Microplasty instrument. This linker connects the IM rod and the femoral drill guide, and the flexion angle of the femoral component is maintained as 10°. Furthermore, it also supports the coronal angle between the IM rod and the femoral drill guide as 7°. Thus, as our results have shown, we could find no outliers in the flexion/extension of the femoral component and more reproducible position of the femoral component might be achieved.

In addition to the IM linker system, there are some more improved designs in this novel instrument. First, the proper size of the femoral component is chosen by both preoperative templating of the lateral radiographs and intraoperative confirming with the femoral sizing spoon. Thus, more appropriate size of the femoral component could be applied to the patients. Second, the total arc of the femoral component is increased and more flexed position of the femoral component could be achieved. The cam impingement of the posterior medial femoral condyle was thought to be a main reason for the polyethylene wear and the dislocation of the mobile-bearing insert [23, 25]. However, in this novel version of instrument, posterior condylar cam might be reduced according to more flexed position of the femoral component. Furthermore, more flexion of the knee joint in daily living activities could be performed, which might be more suitable to the Asian population [9, 26]. Third, different from only one peg in previous femoral components, two pegs are applied to the femoral component. Previous studies already demonstrated that the single-peg design itself was a main reason in increased femoral component loosening [14]. Thus, it is thought that this two-peg design could contribute to increased survival rate of the femoral component.

Improved instruments are also applied to the tibial aspect. When the tibial osteotomy is performed, the femoral sizing spoon and the G-clamp are used. The joint space restoration is performed by capturing the medial femoral condyle with the femoral sizing spoon, and then the G-clamp (3 or 4-mm options) connects the femoral sizing spoon and the tibial cutting guide. This system could prevent excessive tibial condyle cutting which was one of the concerns in the Oxford Phase 3 instrumentation. In our 23 cases, 3 or 4 mm mobile-inserts were used in 20 cases (87.0 %; 10 cases and 10 cases, respectively), and a 5 mm insert was applied in the other 3 cases (23.0%). Considering the correlation with the medial tibial plateau fracture and conversion to the total knee arthroplasty, preservation of larger tibial condyle by less tibial condyle cutting might be an important factor in the tibial preparation.

This noble UKA instrument showed more reproducible and exact radiological results. These positive outcomes might contribute to increasing the patient satisfaction and long-term survivorship of the instrument. Besides, we could expect decreased complication rates such as dislocation of the polyethylene bearing and bearing wear. Although this study demonstrated more satisfactory radiological outcomes in Oxford Microplasty patients, clinical follow-up duration is only from several months to two years. Thus, long term clinical evaluation is necessary to judge the superiority of the novel instrumentation. Furthermore, we reviewed only 23 cases in a single center. To elucidate the efficacy of the noble instrument, a prospective multi-centered trial would be required. Limitation of our study was small number of patient which may decrease the reliability of our analysis.

In conclusion, in order to achieve satisfactory outcomes after unicompartmental knee arthroplasty, optimum position of implant is essential. Significantly higher femoral component flexion and increased total arc of femoral component in Oxford Microplasty® will be more suitable especially for Asian patients who perform more flexion such as squatting and sitting on the floor in daily living activities.

More exact and reproducible positioning of the components, increased flexion position of the femoral component, and reducing impingement on posterior aspect of the medial femoral condyle might increase long-term survivorship of the implant and decrease complication rates such as dislocation of the polyethylene bearing and bearing wear.

Conflicts of interest: none.

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ПОСЛЕОПЕРАЦИОННАЯ РЕНТГЕНОЛОГИЧЕСКАЯ ОЦЕНКА ИНСТРУМЕНТАРИЯ OXFORD MICROPLASTY® ДЛЯ ОДНОМЫЩЕЛКОВОГО ЭНДОПРОТЕЗИРОВАНИЯ КОЛЕННОГО СУСТАВА

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Реферат

Недавно на рынке появилась новая модель эндопротеза Oxford с подвижным вкладышем для одномыщелкового эндопротезирования коленного сустава – UKA, Oxford Microplasty® (Zimmer Biomet, IN, USA), которая является улучшенной версией предыдущей модели – Oxford Phase 3 (Biomet, IN, USA). На настоящий момент в литературе есть только несколько публикаций, демонстрирующих результаты применения нового одномыщелкового эндопротеза.

Цель данного исследования – оценить и представить послеоперационные рентгенологические результаты использования инструментария Oxford Microplasty®.

Материал и методы. С марта по октябрь 2013 г. с применением этого усовершенствованного инструментария было выполнено одномыщелковое эндопротезирование коленного сустава 21 пациенту (23 сустава) с остеоартрозом медиального отдела коленного сустава. Была проведена сравнительная оценка рентгенологических послеоперационных результатов одномыщелкового эндопротезирования коленного сустава (ось конечности и положение компонентов) в этой группе пациентов с результатами одномыщелковой артропластики, выполненной 64 пациентам с использованием Oxford Phase 3 с января 2010 по август 2012 г. Оценивались следующие показатели: до- и послеоперационная деформация коленного сустава во фронтальной плоскости, расположение механической оси по отношению к центру большеберцового плато, положение большеберцового и бедренного компонентов, варусное и вальгусное отклонение большеберцового и бедренного компонентов.

Результаты. В группе пациентов с использованием инструментария Oxford Microplasty® угол HKA (hip-knee-ankle) до операции составлял 172.8±2.5°, а после операции он увеличился до 177.7±2.8° (p<0.001). Существенной разницы между величинами угла HKA в группах с использованием Oxford Phase 3 и Oxford Microplasty выявлено не было: 178.4° и 177.7° соответственно (p>0.05). Также не наблюдалось существенной разницы между этими группами в послеоперационной оси конечности и положении компонентов эндопротеза, за исключением флексии бедренного компонента (11.9±2.1° vs. 2.6±4.1°, p<0.001). Однако в группе пациентов, которым были имплантированы протезы Oxford Microplasty, измерения показали более нейтральную позицию компонентов и меньшее стандартное отклонение. В этой группе также отсутствовали какие-либо выпадающие значения при измерении положения компонентов.

Заключение. Использование инструментария Oxford Microplasty® для одномыщелкового эндопротезирования коленного сустава, в который входит усовершенствованный инструментарий, включая тест-определитель размера бедренного компонента, G-зажим, удлиненный интрамедуллярнвй стержень, бедренный компонент с двумя штифтами и интрамедуллярную звеньевую навигационную систему, обеспечивает точность, эффективность и вопроизводимость операции. Увеличение сгибательного положения и, следовательно, увеличение общей дуги бедренного компонента является более удобным, особенно для жителей Азии, которым свойственно выполнять в быту много сгибательных движений в коленном суставе, таких как сидение на корточках.

Ключевые слова: одномыщелковое эндопротезирование коленного сустава, рентгенологические результаты.

Конфликт интересов: не заявлен.