Effects of Two Different Femoral Referencing Systems in Total Knee Arthroplasty on Immediate to Early Clinical Outcomes

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Purpose: *Basically, there are two different femoral referencing systems in total knee arthroplasty (TKA): anterior referencing system (ARS) and posterior referencing system (PRS). Selected femoral component based on ARS or PRS for individual patient, especially in-between size, which provide good knee kinematics and well soft tissue balance is among one of the surgical goals. However, there are few reports on advantages, disadvantages and clinical outcomes of TKA using both femoral referencing systems. We prospectively evaluated the effect of both femoral referencing systems in TKA on immediate to early clinical outcomes.*

Methods: *Eighty-one patients who had uncomplicated primary unilateral TKA were randomly divided into 2 groups; the ARS group and the PRS group, respectively. All patients underwent similar surgical techniques and postoperative protocol, except the step of femoral sizing according to the ARS group and the PRS group. Knees with measured in-between size of the femoral component were chosen a smaller size in the ARS group and a larger size in the PRS group. Patients were evaluated and compared to range of motion (ROM), visual analog scale (VAS), quadriceps peak torque (QPT), the Knee Society System (KSS) score and Short Form- 36 (SF-36) score, preoperatively, and at 2-week, at 6-week, at 3-month and at 6-month follow-up (FU).*

Results: *There were 61 females and 20 male patients with the average age and BMI of 70.6 years and 27.8 Kg/m2, respectively. Forty-o\ne patients and 40 patients were in the ARS group and the PRS group respectively. Sixteen patients in the ARS group and 17 patients in the PRS group had in-between size of the femoral component. All patients had gradually improved knee ROM, VAS, QPT, KSS score, and SF-36 at all FU visits with significant differences at 6-month compared to preoperative evaluation. There were no statistical differences in all investigated parameters between the ARS group and the PRS group. Similar, at 6-month FU, there were no differences in all investigated parameters of the in-between size subgroup of ARS and PRS. There were no complications related to using both femoral referencing TKA systems.*

Conclusion: *Both ARS and PRS for TKA demonstrated no differences in ROM of the knee, VAS, QPT, KSS score, and SF-36 during follow-up to six months. The concept to select a smaller femoral size for ARS and a larger size for PRS did not provide clinical differences, especially in ROM and QPT at early FU. We concluded that both contemporary TKA knee systems provided similar early clinical outcomes, regardless of matched or in-between femoral size.*

Keywords: *Total knee arthroplasty, TKA, Anterior referencing system, Posterior referencing system*

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Introduction

Total knee arthroplasty (TKA) is one of the potential treatments of end-stage knee osteoarthritis. Moreover, it has provided excellent clinical results; however, excluding postoperative infection and malalignment of the lower limb, many patients still need for revision surgery due to unexplained knee pain[1-3]. Selecting accurate size and positioning of the femoral component to restore normal anatomy of the distal femur are essential for a proper knee kinematics and clinical function of a knee after surgery. In contemporary TKA surgery, there are two major instrumental systems for femoral sizing in sagittal plane: the anterior referencing system (ARS) and the posterior referencing system (PRS). The knees which femoral sizing defines in-between size. Those are

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selected a smaller femoral component that is a cause of flexion instability in ARS or anterior femoral notching in PRS. On the other hand, selection of a larger femoral component may cause tight flexion gap in ARS or anterior femoral overstuff in PRS. Therefore, a selected femoral component based on using ARS or PRS for individual patient, especially for the knee with in-between size measurement. The proper femoral size will provide good knee kinematics and good soft tissue balance[4-9]. However, there are few reports about advantages, disadvantages and compared clinical outcomes of TKA when using both femoral referencing systems[10]. The purpose of our study compared immediate to early clinical outcomes of patients who underwent TKA by using ARS or PRS for femoral sizing.

Materials and Methods

The present study was approved by institutional board review, and was conducted from July 2013 till July 2014. Eighty-one candidates who underwent uncomplicated unilateral primary TKA were recruited. Inclusion criteria included patients with the American Society of Anesthesiologists (ASA) physical status I to III, no previous knee surgery, knee angular deformity within 10 degrees of anatomical varus or valgus, and knee range motion more than 90 degrees. Exclusion criteria included inflammatory knee arthritis, history of stroke or neurological deficit, sensory and motor disorders in the operated limb, having contralateral TKA less than 6-month period after the first TKA, and a subject-refusal. Patients were prospectively randomized by computer-based randomization with simple type technique into 2 groups then the patients in each group need to pick up more than 40 persons by reference to pervious papers[11-13]: the ARS and PRS groups were accorded to use of ARS or PRS at the time of surgery. The minimally invasive midvastus approach with minimally invasive surgery (MIS) instrumentation was used in all cases. All patients received spinal bock for the choice of anesthesia. All surgical steps were similarly performed in both groups, including distal femoral bone cut, proximal tibial bone cut, 3-degree femoral rotation and sizing based on ARS or PRS, final femoral bone cuts, gap balancing, tibial sizing, patellar preparation, and trial reduction with range of motion (ROM) and stability tests. Based on the recommended surgical manual of MIS instruments for femoral sizing, the NexGen LPS knee system (Zimmer Biomet, Warsaw, IN, USA) was used for the ARS group and the Vanguard PS knee system (Zimmer Biomet, Warsaw, IN, USA) was used for the PRS group. In the knees with measured in-between size of the femoral component, a smaller size was chosen for the ARS group and a larger size was chosen for the PRS group.

All patients had the same perioperative pain management and a perioperative rehabilitation protocol. The postoperative protocol consists of start range of motion of operated knee as soon as patients are able to tolerate and also start ankle foot pumping after run out of anesthesia on their leg. Day 2 after surgery, all patients are encouraged to walk with walker by assistants. Patients were evaluated for knee ROM, visual analog scale (VAS), quadriceps peak torque (QPT), Knee Society System (KSS) score and Short form-36 (SF-36) score by two independent orthopedists, pre- and postoperatively. Regarding QPT measurement, the test was performed using a digital dynamometer (MicroFET2TM, Hoggan Health Industries, Salt Lake City, UT, USA). In each evaluation for quadriceps strength, the patient was asked to do straight leg raising from sitting position, while the blind evaluator pushed the digital dynamometer on mid-leg against the patient's force until the maximum force that the patient could withstand the straight leg position. Regarding visual analog scale (VAS), which is generally acknowledged to have good reliability and validity for evaluated passive outcome from patients[14,15] , has scale ranges from 0 (poorest status) to 100 points (best status). The SF-36, which consists of 36 items, is assigned to 8 subscales: physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role and mental health. All parameters were assessed at the time of preoperative, at 2 and 6 week, 3 and 6 month postoperatively. However, the radiographic evaluation was performed at 6 month postoperatively only.

Statistical analysis for all variable parameters was calculated by using SPSS software version 20. Comparative statistics included independent t-Test for continuous data and chi-square for qualitative data. Significant value was defined if the difference was below than 0.05.

Results

Among 81 patients, there were 40 patients (40 knees) in the ARS group and 41 patients (41 knees) in the PRS group. The average age and body mass index (BMI) of the studied groups was 70.6 years and 27.8 kg/m^2, respectively. There were no significant differences in demographic data between two groups as showed in Table 1**.** There were 16 and 17 patients whose knees were defined as in-between size for the femoral component in ARS and PRS groups respectively with no differences in operative time and drainage blood loss between both groups (Table 1).

Regarding pre- and postoperative clinical outcomes, there were no significant differences between two groups in terms of knee ROM, VAS, QPT, KSS Score, and SF-36 survey at preoperative

evaluation. At follow-up visit, both groups had similarly investigated parameters at all follow-up visits after surgery as showed in Table 2-6. Similarly, at 6-month FU, there were no differences in all investigated parameters in in-between size subgroup of both ARS and PRS groups (Table 7-8). There was no readmission or no reoperation of the whole studied groups.

Table 1 Demographic data with included intraoperative data

Parameters	**Total** N = 81	**ARS** N =41	**PRS** N =40	***P*-value**
Female	61	34	27	0.11
Male	20	7	13	0.08
Mean age (years)	70.6	71.5	69.7	0.22
Mean BMI (kg/m^2)	27.78	27.49	28.07	0.47
In-between femoral sizing (number)	33	16	17	0.82
Mean drainage blood loss (ml)	398.5	425.6	372.5	0.18
Mean operative time (min)	103	102.43	103.87	0.78

ARS: anterior referencing system
PRS: posterior referencing system

Table 2 Knee range of motion

Parameters	**Total** degree	**ARS** degree	**PRS** degree	***P*-value**
Preoperative	115.2	114.1	116.4	0.56
2-week FU	99.6	97.9	101.4	0.17
6-week FU	116.5	116.5	116.6	0.94
3-month FU	116.8	117.0	116.7	0.89
6-month FU	120.5	122.0	119.8	0.88

ARS: anterior referencing system
PRS: posterior referencing system

Table 3 Quadriceps peak torque

Parameters	**Total** N/m^2	**ARS** N/m^2	**PRS** N/m^2	***P*-value**
Preoperative	118.0	112.4	123.7	0.58
2-week FU	74.7	73.8	75.7	0.7
6-week FU	120.7	121.8	119.5	0.65
3-month FU	125.9	127.1	126.7	0.57
6-month FU	140.7	136.6	144.8	0.3

ARS: anterior referencing system
PRS: posterior referencing system

Table 4 Visual analog scale

Parameters	**Total**	**ARS**	**PRS**	***P*-value**
Preoperative	8.0	8.2	7.8	0.14
2-week FU	3.5	3.3	3.7	0.27
6-week FU	1.1	1.2	1.1	0.68
3-month FU	0.8	0.9	0.7	0.48
6-month FU	0.7	0.8	0.7	0.8

ARS: anterior referencing system
PRS: posterior referencing system

Table 5 Knee Society System score

Parameters	**Total** points	**ARS** points	**PRS** points	***P*-value**
Preoperative	36.22	36.8	35.62	0.6
2-week FU	71.52	72.63	70.38	0.39
6-week FU	85.38	85.02	85.75	0.65
3-month FU	86.43	86.34	86.53	0.89
6-month FU	87.5	88.2	86.33	0.83

ARS: anterior referencing system
PRS: posterior referencing system

Table 6 Short Form-36 score

Parameters	**Total** points	**ARS** points	**PRS** points	***P*-value**
Physical health				
Preoperative	40	32.9	31.3	0.68
3 months	55.2	52.5	54.3	0.21
Metal health				
Preoperative	68.1	66.3	64.5	0.73
3 months	72.7	69.8	70.7	0.52

ARS: anterior referencing system
PRS: posterior referencing system

Table 7 Anterior referencing system

At 6-month FU	**Matched size**	**In-between size**	***P*-value**
Knee range of motion (degree)	112	115	0.42
Quadriceps peak torque (N/m^2)	136	132	0.8
Visual analog scale	0.7	0.7	1
Knee Society System score (point)	85	80	0.53
Short Form-36 score (point)			
Physical health	52	54	0.8
Metal health	71	72.5	072

Table 8 Posterior referencing system

At 6-month FU	**Matched size**	**In-between size**	***P*-value**
Total knee range of motion (degree)	112	112	1
Quadriceps peak torque (N/m^2)	136	144	0.1
Visual analog scale	0.7	0.5	0.8
Knee Society System score (points)	85	88	0.82
Short Form-36 score (points)			
Physical health	52	55	0.7
Metal health	71	72	0.9

Discussion

Previous studies reported that, at TKA surgery, the step of femoral sizing was important as it played key role for restoring the center of rotation in sagittal plane[16,17]. Malalignment of the femoral component in flexion and extension might relate to poor results and early failure of TKA, although poor results of TKA have been more recognized in coronal imbalance than sagittal imbalance[18]. Besides other surgical steps in TKA, precision of sizing of the femoral component which restores the femoral geometry should provide the optimum knee kinematics and clinical results; however, Nandi et al[19] found that the selected size of femoral component during TKA might be variable depending on surgeon's decision and anatomical referencing points. The knee with in-between femoral sizing, selection is either a smaller

or a larger femoral component. A smaller component may cause flexion instability in ARS or may cause anterior femoral notching in PRS. On the other hand, a larger component may cause tight flexion gap in ARS or anterior femoral overstuff in PRS. Therefore, surgeons who use an anterior referencing system for femoral sizing tend to choose the smaller femoral size in order to avoid too tight flexion gap. On the opposite way, surgeons who use a posterior referencing system tend to choose the larger femoral size in order to prevent anterior notching of the distal femur. Although there is one study reported that choosing a larger femoral size increased load to peripheral tibial polyethylene and predisposed early failure[20], another study found that choosing femoral component which was based on different referencing systems resulted in similar clinical outcome[10].

According to Fokin et al[10], comparing anterior with posterior referencing systems found that Knee society scores, SF-12, range of motion and strength testing were similar in all groups. In agreement with this study, the present study found no statistical differences of using ARS or PRS for femoral sizing, in terms of knee ROM, VAS, QPT, KSS scores andSF-36 scores at follow-up from 2 weeks to 6 months, regardless of matched size or in-between size of both groups. These findings might relate to using of contemporary total knee systems in the present study. The NexGen and the Vanguard knee systems has 4-mm and 2.5-mm increment for each femoral size; therefore, increasing of the size is less than significance in clinical changes.

In the present study, selected smaller femoral size for in-between size measurement could affect a maximum of 3-mm increased flexion gap for the ARS group, which might cause loose flexion gap. According to Manson et al[16], changing in size under ARS technique has effects on flexion gap and sagittal plane balance; however, presently, there is no comparative data that compares ARS and PRS technique about loosening in flexion gap when using in the same size. Additionally, selected larger femoral size for in-between size measurement could affect a maximum of 1.5-mm anterior overstuff for the PRS group, which might cause limited knee flexion. However, in the in-between subgroup of ARS and APS, we did not find any differences, in terms of knee ROM, VAS, QPT, KSS scores andSF-36 scores at all FU visits.

Consequently, we believed that the ARS group might have looser flexion gap than the PRS group in longer follow-up that is discussed as the limitation of the study.

There are a few limitations of the present study. Firstly, although it was a prospective randomize control trial which has showed similar immediate to early clinical results of both groups, the progressive soft tissue laxity at longer FU might affect the long-term outcomes, especially knee flexion instability of the ARS group. Secondly, we did not demonstrate any complication related to choosing in-between size of the femoral components in both groups.

Finally, the number of in-between size patients is small; therefore, if the further study modified by increasing the size in this group the result may distinguish from our study.

Conclusion

Both ARS and PRS for TKA demonstrated no differences in terms of the knee ROM, VAS, QPT, KSS score, and SF-36 until 6-month FU. The concept to select a smaller femoral size for ARS and a larger size for PRS did not provide clinical differences, especially knee ROM and QPT at early FU. We concluded that both contemporary TKA knee systems provided similar early clinical outcomes, regardless of matched or in-between femoral size.

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ผลทางคลินิกระยะแรกหลังจากการผ่าตัดเปลี่ยนข้อเข่าเทียมโดยการใช้เครื่องมือผ่าตัดที่อ้างอิงกระดูกฟีเมอร์จากด้านหน้าและด้านหลัง

วิทวัส บุญญานุวัตร, พบ, อารี ตนาวลี, พบ, นที ธนทรัพย์สิน, พบ, สีหธัช งามอุโฆษ, พบ

ภูมิหลัง: ในการผ่าตัดเปลี่ยนข้อเข่าเทียมนั้น มีวิธีการวัดขนาดข้อเทียมส่วนกระดูกฟีเมอร์ (femur) สองวิธี คือ การวัดโดยใช้เครื่องมือผ่าตัดที่อ้างอิงกระดูกฟีเมอร์จากด้านหน้า (anterior referencing system, ARS) และด้านหลัง (posterior referencing system, PRS) การเลือกวิธีใดวิธีหนึ่งสำหรับผู้ป่วยแต่ละรายโดยเฉพาะผู้ที่วัดขนาดได้ระหว่างสองขนาด (in-between size) ต้องได้วัตถุประสงค์สำคัญในการผ่าตัด คือข้อเข่ามีกลศาสตร์เชิงกลที่ดีและได้รับปรับความสมดุลของเนื้อเยื่อที่ดี แต่อย่างไรก็ตาม มีการรายงานเกี่ยวกับผลดีผลเสีย และผลทางคลินิกเปรียบเทียบระหว่างวิธีการทั้งสองจำนวนน้อย เราจึงสนใจศึกษาแบบไปข้างหน้าของการใช้เครื่องมือผ่าตัดที่ทั้งสองวิธีเพื่อประเมินผลทางคลินิกระยะแรกหลังจากการผ่าตัด

วิธีการศึกษา: ผู้ป่วย 81 ราย ซึ่งได้รับการผ่าตัดข้อเข่าเทียมแบบปฐมภูมิ 1 ข้าง ถูกสุ่มแบ่งออกเป็น 2 กลุ่ม คือ กลุ่มที่เลือกใช้ ARS และ กลุ่มที่เลือกใช้ PRS ตามลำดับ โดยผู้ป่วยทั้งหมดได้รับขั้นตอนการผ่าตัด และการดูแลหลังผ่าตัดเหมือนกัน ยกเว้นขั้นตอนในการวัดขนาดกระดูกฟีเมอร์ซึ่งทำตามวิธีวัดแบบ ARS และ PRS ตามกลุ่ม ส่วนข้อเข่าที่วัดได้ขนาดอยู่ระหว่างกึ่งกลางของสองขนาดนั้น จะเลือกขนาดเล็กกว่าสำหรับกลุ่มที่ใช้จุดอ้างอิงทางด้านหน้า และขนาดใหญ่กว่าสำหรับกลุ่มที่ใช้จุดอ้างอิงทางด้านหลัง ผู้ป่วยทุกคนจะถูกประเมินเพื่อเปรียบเทียบพิสัยของการเคลื่อนไหว (range of motion) ค่าความเจ็บปวด (visual analog scale) ค่าความแข็งแรงของกล้ามเนื้อต้นขา (quadriceps peak torque) ค่า Knee Society System และ Short form-36 ก่อนผ่าตัด ที่ 2 สัปดาห์ ที่ 6 สัปดาห์ ที่ 3 เดือน และที่ 6 เดือนของการติดตามอาการ

ผลการศึกษา: มีผู้ป่วยหญิง 61 ราย และชาย 20 ราย โดยผู้ป่วยมีอายุเฉลี่ยและค่าดัชนีมวลกาย เท่ากับ 70.6 ปี และ 27.8 กิโลกรัมต่อตารางเมตรตามลำดับ ผู้ป่วย 41 ราย และ 40 ราย ถูกจัดอยู่ใน ARS และ PRS ตามลำดับ ผู้ป่วย 16 ราย และ 17 รายมีข้อเข่าที่วัดได้ขนาดอยู่ระหว่างกึ่งกลางของสองขนาดของกลุ่ม ARS และ PRS ตามลำดับ ผู้ป่วยทุกรายมีเปลี่ยนแปลงที่ดีขึ้นของพิสัยของการเคลื่อนไหว visual analog scale, quadriceps peak torque, คะแนน Knee Society System และคะแนน Short Form-36 ที่ดีขึ้นอย่างมีนัยสำคัญเมื่อเปรียบเทียบกับก่อนผ่าตัดและที่เวลา 6 เดือน โดยไม่มีความแตกต่างการทางสถิติของทุกค่าการศึกษาระหว่างกลุ่ม ARS และ PRS รวมถึงไม่มีความแตกต่างการทางสถิติของทุกค่าการศึกษาในกลุ่มย่อยที่วัดได้ขนาดอยู่ระหว่างกึ่งกลางของสองขนาดไม่มีผลแทรกซ้อนที่เกิดขึ้นจากการผ่าตัดโดยใช้วิธีทั้งสองวิธี

สรุป: งานวิจัยเปรียบเทียบนี้พบว่าวิธีการวัดขนาดข้อเทียมส่วนกระดูกฟีเมอร์ในการผ่าตัดข้อเข่าเทียมโดยใช้เครื่องมือผ่าตัดที่อ้างอิงกระดูกฟีเมอร์จากด้านหน้า(ARS) และด้านหลัง (PRS) ไม่มีความแตกต่างกันของพิสัยของการเคลื่อนไหว visual analog scale, quadriceps peak torque, คะแนน Knee Society System และคะแนน Short Form-36 ตั้งแต่ 2 สัปดาห์จนถึง 6 เดือนของการติดตามผู้ป่วยในกลุ่มย่อยที่วัดได้ขนาดระหว่างกึ่งกลางของสองขนาด การเลือกข้อเทียมส่วนกระดูกฟีเมอร์ที่ขนาดเล็กลงในกลุ่มผู้ป่วย ARS และขนาดใหญ่ขึ้นในกลุ่มผู้ป่วย PRS ไม่ส่งผลให้มีความแตกต่างกันในทางคลินิกโดยเฉพาะพิสัยการเคลื่อนไหว และ quadriceps peak torque ในการติดตามผู้ป่วยระยะแรก คณะผู้วิจัยสรุปว่าการใช้เครื่องมือผ่าตัดที่อ้างอิงกระดูกฟีเมอร์ทั้งสองวิธีได้ผลทางคลินิกระยะแรกเหมือนกัน โดยไม่ขึ้นกับว่าจะวัดขนาดกระดูกฟีเมอร์ได้พอดีหรือวัดได้ขนาดกึ่งกลาง