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Knee Flexion Angle Following Total Knee Arthroplasty Relates to a Preoperative Range of Motion of the Hip

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Title

Knee flexion angle following total knee arthroplasty relates to a preoperative range of motion of the hip

Abstract

Background

Many factors have been reported to affect postoperative range of knee flexion after total knee arthroplasty (TKA), however, no study has reported the impact of preoperative range of motion of the hip to the postoperative flexion angle of the knee thus far.

Methods

Of 38 consecutive patients who underwent posterior-stabilized TKA, we assessed 21 patients after excluding 17 patients who met exclusion criteria. The range of motion of the knee and the hip, age, body-mass index, serum albumin level, HbA1c, Kellgren-Lawrence grade, knee extension strength and radiological femorotibial angle as well as postoperative knee flexion angle at three months were evaluated. The preoperative data and the knee flexion angle at three months after TKA were compared using Spearman's rank correlation coefficient.

Results

Knee flexion angle at three months after TKA was positively correlated with preoperative flexion ($\rho = 0.616$, $p = 0.007$) and external rotation angle ($\rho = 0.576$, $p = 0.012$) of the hip as well as preoperative knee flexion angle ($\rho = 0.797$, $p = 0.001$).

There were no correlations between postoperative knee flexion angle and other preoperative data.

Conclusions

Patients with restricted flexion and/or external rotation of the hip may have contractures of Gluteus maximus, Gluteus medius and Tensor fasciae latae, which can cause hypertension of iliotibial tract. It may cause decreased internal rotation of the tibia when the knee is flexed, which affects postoperative knee flexion angle, thus limited flexion and/or external rotation of the hip might restrict knee flexion angle following TKA.

Keywords: total knee arthroplasty; range of motion of the hip; knee flexion angle; iliotibial tract

1. Introduction

Primary total knee arthroplasty (TKA) has proven to be a highly successful surgical procedure over the past 20 years, with survivorship rates after a 15-year follow-up period approaching 95% [1-3]. The objectives of TKA are to achieve a good postoperative range of motion (ROM) and walking without pain. Patients in Asian as well as Middle Eastern countries who are planning to have TKA usually expect to be able to perform activities requiring deep knee flexion such as sitting cross-legged or kneeling with ease after TKA [4]. Minimum 110° of knee flexion is needed to achieve up and down stairs smoothly and to get up from a chair [5,6]. It was reported that postoperative ROM can be affected by several factors such as the patient's preoperative ROM of the knee, diagnosis, gender, age, body-mass index (BMI), the surgeon's technique, the pre- and postoperative rehabilitation program, and the design of the prosthesis [7,8]. Intracapsular factors such as varus/valgus ligament balance, flexion-extension gap balance, the height of the joint line, posterior condylar offset, tibial slope, and patella resurfacing, have also been discussed by several authors [9-11].

In case the compensatory mechanisms between joints are weakened or the mechanical load to the adjacent joint increases, new pathological condition can occur and influences each other between joints, such as hip-spine syndrome [12], knee-spine syndrome [13], and coxitis knee [14]. Few studies have examined the influence of other joints to the flexion angle of the knee, and as far as we are aware, there has been no study which has reported that preoperative hip ROM affects the flexion angle of the knee after TKA. In this study, we tried to investigate whether the preoperative ROM of the hip influences the flexion angle of the knee after TKA.

2. Materials and Methods

The study was approved by the Institutional Review Board of our institution, and written informed consent was obtained from the patients. We prospectively reviewed 38 consecutive patients with substantial pain and loss of function due to osteoarthritis of the knee who underwent posterior-stabilized TKA (Vanguard Posterior-Stabilized; Zimmer Biomet, Warsaw, IN, USA) (Figure 1) at our institution between November 2018 and August 2019. Seventeen patients were excluded from the study as they met the exclusion criteria (Table 1). The remaining 21 patients, including one man and 20 women with a mean age of 74.4 years (range, 62–83 years; standard deviation (SD), 6.7) at the time of TKA, were enrolled in the study.

The patients' preoperative data were evaluated based on the ROM (°) of the knee (flexion and extension) and the hip (flexion, extension, abduction, adduction, internal rotation and external rotation), age (years), BMI (kg/m^2), serum albumin level (g/dl), HbA1c (%), Kellgren- Lawrence grade, knee extension strength (N/kg) and radiological femorotibial angle (FTA) (°). The knee flexion angle (°) was evaluated at three months after TKA.

Full-length weight-bearing radiographs including the hip, knee, and ankle joints were obtained before surgery. The angle of the bone cuts and the desired position of the entry hole of the femur were planned before the operation. Prophylactic antibiotics were administered immediately before the skin incision. A bloodless field was obtained with the use of a pneumatic tourniquet at a pressure of 250 mm Hg after exsanguination with an Esmarch bandage. After inflating the air tourniquet with the knee flexed, a longitudinal midline skin incision (approximately 10–12 cm in length) was used in all the cases. Knees were exposed by medial parapatellar arthrotomy, and osteotomy was performed using the measured resection technique. A medial step-by-step soft tissue release was performed depending on the amount of imbalance. Tibial resection was performed using an extramedullary guiding rod, and femoral resection was performed using an intramedullary guiding rod. The posterior femoral osteotomy was performed and the femoral component size was determined using posterior referencing, with care taken to maintain the posterior condylar offset. The femoral component was placed in 3° of external rotation to the femoral posterior axis; this position was achieved by using the anteroposterior trochlear sulcus as a reference. A proximal tibial osteotomy was performed perpendicular to the long axis

in the coronal plane with a posterior slope of 7° in the sagittal plane. The tibial bony cut was made ten millimetres below the highest point of the articular cartilage on the lateral tibial plateau. Akagi line (mid-posterior cruciate ligament (PCL) to the medial border of the tibial tubercle) [15] was used to determine the rotational alignment of the tibial component. Stability and alignment were assessed using the trial components, and the varus-valgus balancing of the soft tissues was ascertained in both flexion and extension. All the femoral and tibial prostheses were fixed with cement after pulsed lavage, drying, and pressurisation of the cement. Patellar resurfacing was conducted in all cases.

On the first or second postoperative day, patients began active knee motion exercises with quadriceps-strengthening exercises and standing at the bedside or walking with crutches or a walker under the supervision of a physical therapist. The patients were allowed to use crutches or a walker with full weight-bearing after surgery. Five to seven days after surgery, patients were discharged from a hospital, and physical therapy at the outpatient clinic was conducted once a week for three months after surgery.

ROM of the hip and the knee was measured using a goniometer in the supine position by more than one senior physiotherapist with clinical experiences for more than five years. Knee extension strength was measured using hand-held dynamometer μTas F-1 (Anima Corporation; Tokyo, Japan) with knees flexed at 75° in a sitting position.

All of the clinical and radiological data of the 21 patients were reviewed by an experienced orthopaedic surgeon who had no connection to the surgery, and the results were entered into a computerised record. All statistical analyses were performed using Microsoft Excel 2013 (Microsoft Corporation, Redmond, Washington, USA). The preoperative data and the knee flexion angle at three months after TKA were compared using Spearman's rank correlation coefficient. $P < 0.05$ was considered to indicate statistical significance.

3. Results

Mean operative time was 80.4 ± 10.1 minutes. Among the 21 knees included in the study, failure due to varus-valgus joint instability in flexion or extension, supracondylar femoral fracture, fracture of the tibial post, peroneal nerve palsy, deep or superficial infection, or aseptic loosening of the component assessed by radiographs has not occurred. No revision surgery was performed or planned by the final follow-up.

Results of Spearman's rank correlation coefficient between the preoperative data and knee flexion angle at three months after TKA were shown in Table 2. Knee flexion angle at three months after TKA was positively correlated with preoperative flexion ($\rho = 0.616$, $p = 0.007$) and external rotation angle ($\rho = 0.576$, $p = 0.012$) of the hip as well as preoperative knee flexion angle ($\rho = 0.797$, $p = 0.001$). There was no correlation between postoperative knee flexion angle and the other preoperative parameters.

On the other hand, no statistically significant correlations between preoperative knee flexion angle and flexion ($\rho = 0.314$, $p = 0.166$) or external rotation angle ($\rho =$

148 0.294, p = 0.196) of the hip were found.

149

150

4. Discussion

In this study, we showed that the flexion angle of the knee at three months after TKA was positively correlated with preoperative flexion and external rotation angle of the hip as well as preoperative knee flexion angle, which suggested the importance of the range of these motions to achieve better postoperative knee flexion angle following TKA. Range of knee flexion is reported to be associated with postoperative patient satisfaction [5,16]. Many factors affect postoperative range of knee flexion, including sex, age, preoperative range of knee flexion, BMI, prosthetic design and size, and surgical technique [17-20]. Of these, the importance of a preoperative range of knee flexion has been reported [21,22]. As with these past studies, in the current study, we showed the positive correlation between preoperative knee flexion angle and postoperative knee flexion angle following TKA. However, to the best of our knowledge, few studies have reported the influence of ROM of the hip to the flexion angle of the knee, and this is the first study which reported the relationship between preoperative ROM of the hip and postoperative knee flexion angle following TKA.

Relationship between the hip and the knee has been studied from the viewpoint of the initiation of osteoarthritis. The secondary knee osteoarthritis which occurs due

169 to hip osteoarthritis is known as coxitis knee. Adduction contracture of the hip has
170 been regarded as the main aetiology of coxitis knee [14]. In the current study, there
171 was no relationship between preoperative range of adduction/abduction of the hip
172 and postoperative knee flexion angle following TKA. Therefore, we assume the
173 mechanism of coxitis knee and that of restricted knee flexion angle after TKA may be
174 different, and there needs to be another explanation.
175
176 Delp et al reported that the flexion angle of the hip was restricted by the contracture
177 of Gluteus maximus and Gluteus medius as well as six deep external rotators, i.e.,
178 Piriformis, Germellus superior, Obturator internus, Germellus inferior, Obturator
179 externus and Quadratus femoris, by examining a three-dimensional computer model
180 of the hip muscles and the experimental measurements using cadaver models [23].
181 Also, Dostal et al reported that the external rotation of the hip was restricted by the
182 contracture of Gluteus medius, Gluteus minimus and Tensor fasciae latae by
183 examining a three-dimensional straight-line geometrical model of the hip
184 musculature [24]. Of these muscles, Gluteus maximus, Gluteus medius and Tensor
185 fasciae latae are connected to iliotibial tract (ITT). Therefore, contracture of these
186 muscles may cause increased tension and contracture of ITT. ITT partially attaches to

187 Gerdy's tubercle and restricts internal rotation of the tibia in the knee flexed, so
188 hypertension or contracture of ITT may cause decreased internal rotation of the tibia
189 when the knee is flexed [25]. Matsuzaki et al assessed kinematic factors affecting
190 postoperative knee flexion after TKA by analysing pre- and postoperative knee
191 kinematics using a navigation system, and they reported that postoperative knee
192 flexion angle was significantly correlated with postoperative tibial internal rotation
193 [26]. From the above, we consider that patients with limited flexion and/or external
194 rotation of the hip may have contractures of Gluteus maximus, Gluteus medius and
195 Tensor fasciae latae, and they decrease internal rotation of the tibia in the knee flexed
196 through overstrained ITT, which may restrict knee flexion angle following TKA.
197
198 The present study has several limitations. Firstly, the number of samples was small
199 and power analysis was not conducted. Secondly, the study population was limited
200 to patients with varus-type osteoarthritis and excluded osteoarthritic knees with
201 large bony defects. Valgus and severe osteoarthritic knees need to be assessed and
202 compared with the populations in this series. Thirdly, TKAs using only one PS-type
203 prosthesis (Vanguard posterior-stabilized) were included in this study. Different
204 designs such as cruciate-retaining (CR)-type prostheses may offer varying results.

Additionally, using other PS-type prostheses with different level of conformity between the tibial insert and femoral component may change the results. Additional studies using different implant designs are necessary to further examine the relationship between preoperative ROM of the hip and postoperative knee flexion angle following TKA. Fourthly, regression analysis was not conducted because the number of cases was small, while it needs to be performed to draw a strong conclusion. Fifthly, all the cases were conducted by a single surgeon. A multi-centre study including several surgeons will be required in the future study. Sixthly, we have not taken confounding pathologies or aetiology of hip restriction into consideration. For example, external rotation of the hip was reported to be restricted in a patient with sacroiliac joint diseases [27]. Also, it is said that flexion of the hip is restricted in a patient with femoroacetabular impingement [28] or subspine impingement [29]. Lastly, in this study, we have not measured the range of internal rotation of the tibia. It should be determined to reinforce our theory in the future.

5. Conclusion

The results of this study suggested the importance of the range of external rotation and flexion of the hip to achieve better postoperative knee flexion angle following TKA. Further studies including regression analysis with a large number of cases using a variety of types of prostheses are needed.

228 **Conflict of interest:** The authors declare that they have no conflict of interest.

229 **Funding:** Nil

230

References

1. Argenson JN, Boisgard S, Parratte S, Descamps S, Bercovy M, Bonnevialle P, Briard JL, Brilhault J, Chouteau J, Nizard R, Saragaglia D, Servien E, French Society of Orthopedic and Traumatologic Surgery (SOFCOT). Survival analysis of total knee arthroplasty at a minimum 10 years' follow-up: a multicenter French nationwide study including 846 cases. Orthop Traumatol Surg Res. 2013 Jun;99(4):385-390.

2. Jauregui JJ, Cherian JJ, Pierce TP, Beaver WB, Issa K, Mont MA. Long-Term Survivorship and Clinical Outcomes Following Total Knee Arthroplasty. J Arthroplasty. 2015 Dec;30(12):2164-2166.

3. Victor J, Ghijselings S, Tajdar F, Van Damme G, Deprez P, Arnout N, Van Der Straeten C. Total knee arthroplasty at 15-17 years: does implant design affect outcome? Int Orthop. 2014;38(2):235-241, Feb 2014

4. Kurosaka M, Yoshiya S, Mizuno K, Yamamoto T. Maximizing flexion after total knee arthroplasty: the need and the pitfalls. J Arthroplasty. 2002;17(4 Suppl 1):59-62, Jun 2002

5. Devers BN, Conditt MA, Jamieson ML, Driscoll MD, Noble PC, Parsley BS. Does greater knee flexion increase patient function and satisfaction after total knee

arthroplasty? J Arthroplasty. 2011;26(2):178-186, Feb 2011

6. Rowe PJ, Myles CM, Walker C, Nutton R. Knee joint kinematics in gait and other functional activities measured using flexible electrogoniometry: how much knee motion is sufficient for normal daily life? Gait Posture. 2000;12(2):143-155, Oct 2000

7. Ritter MA, Harty LD, Davis KE, Meding JB, Berend ME. Predicting range of motion after total knee arthroplasty. Clustering, log-linear regression, and regression tree analysis. J Bone Joint Surg Am. 2003;85(7):1278-1285, Jul 2003

8. Pasquier G, Tillie B, Parratte S, Catonné Y, Chouteau J, Deschamps G, Argenson JN, Bercovy M, J Salleron. Influence of preoperative factors on the gain in flexion after total knee arthroplasty. Orthop Traumatol Surg Res. 2015;101(6):681-685, Oct 2015

9. Goldstein WM, Raab DJ, Gleason TF, Branson JJ, Berland K. Why posterior cruciate-retaining and substituting total knee replacements have similar ranges of motion. The importance of posterior condylar offset and cleanout of posterior condylar space. J Bone Joint Surg Am. 2006;88 Suppl 4:182-188, Dec 2006

10. Massin P, Gournay A. Optimization of the posterior condylar offset, tibial slope,

and condylar roll-back in total knee arthroplasty. J Arthroplasty. 2006;21(6):889-896, Sep 2006

11. Mizu-uchi H, Colwell CW, Jr., Matsuda S, Flores-Hernandez C, Iwamoto Y, D'Lima DD. Effect of total knee arthroplasty implant position on flexion angle before implant-bone impingement. J Arthroplasty. 2011;26(5):721-727, Aug 2011

12. Offierski CM, MacNab I. Hip-spine syndrome. Spine. 1983;8(3):316-321, Apr 1983

13. Murata Y, Takahashi K, Yamagata M, Hanaoka E, Moriya H. The knee-spine syndrome. Association between lumbar lordosis and extension of the knee. T J Bone Joint Surg Br. 2003;85(1):95-99, Jan 2003

14. Tsubosaka M, Matsumoto T, Takayama K, Nakano N, Kuroda R. Two cases of late medial instability of the knee due to hip disease after total knee arthroplasty. Int J Surg Case Rep. 2017;37:200-204, 2017

15. Akagi M, Oh M, Nonaka T, Tsujimoto H, Asano T, Hamanishi C. An anteroposterior axis of the tibia for total knee arthroplasty. Clin Orthop Relat Res. 2004;420:213-219, Mar 2004

16. Matsuda S, Kawahara S, Okazaki K, Tashiro Y, Iwamoto Y. Postoperative

alignment and ROM affect patient satisfaction after TKA. Clin Orthop Relat Res. 2013;471(1):127-133, Jan 2013

17. Matsumoto T, Tsumura N, Kubo S, Shiba R, Kurosaka M, Yoshiya S. Influence of hip position on knee flexion angle in patients undergoing total knee arthroplasty. J Arthroplasty. 2005;20(5):669-673, Aug 2005

18. Ritter MA. High-flexion knee designs: more hype than hope? In the affirmative. J Arthroplasty. 2006;21(4 Suppl 1):40-41, Jun 2006

19. Schirm AC, Jeffcote BO, Nicholls RL, Jakob H, Kuster MS. Sensitivity of knee soft-tissues to surgical technique in total knee arthroplasty. Knee. 2011;18(3):180-184, Jun 2011

20. Schurman DJ, Rojer DE. Total knee arthroplasty: range of motion across five systems. Clin Orthop Relat Res. 2005;430:132-137, Jan 2005

21. Anouchi YS, McShane M, Kelly F, Jr., Elting J, Stiehl J. Range of motion in total knee replacement. Clin Orthop Relat Res. 1996;331:87-92, Oct 1996

22. Lizaur A, Marco L, Cebrian R. Preoperative factors influencing the range of movement after total knee arthroplasty for severe osteoarthritis. J Bone Joint Surg Br. 1997;79(4):626-629, Jul 1997

23. Delp SL, Hess WE, Hungerford DS, Jones LC. Variation of rotation moment

303 arms with hip flexion. J Biomech. 1999;32(5):493-501, May 1999
304 **24.** Dostal WF, Soderberg GL, Andrews JG. Actions of hip muscles. Phys Ther.
305 1986;66(3):351-361, Mar 1986
306 **25.** Kittl C, El-Daou H, Athwal KK, Gupte CM, Weiler A, Williams A, Amis AA. The
307 Role of the Anterolateral Structures and the ACL in Controlling Laxity of the
308 Intact and ACL-Deficient Knee: Response. Am J Sport Med. 2016;44(4):15-18,
309 Apr 2016
310 **26.** Matsuzaki T, Matsumoto T, Muratsu H, Kubo S, Matsushita T, Kawakami Y,
311 Ishida K, Oka S, Kuroda R, Kurosaka M. Kinematic factors affecting
312 postoperative knee flexion after cruciate-retaining total knee arthroplasty. Int
313 Orthop. 2013;37(5):803-808, May 2013
314 **27.** Adhia DB, Tumilty S, Mani R, Milosavljevic S, Bussey MD. Can hip abduction
315 and external rotation discriminate sacroiliac joint pain? Man Ther. 2016;21:191-
316 197, Feb 2016
317 **28.** Nakano N, Khanduja V. Femoroacetabular impingement: the past, current
318 controversies and future perspectives. Phys Sportsmed. 2018;46(3):270-272,
319 Sep 2018
320 **29.** Nakano N, Yip G, Khanduja V. Current concepts in the diagnosis and

321 management of extra-articular hip impingement syndromes. Int Orthop.
322 2017;41(7):1321-1328, Jul 2017
323

Figure captions

Figure 1

Vanguard Posterior-Stabilized; Zimmer Biomet, Warsaw, IN, USA

Figure 1



Table 1

Exclusion criteria of the study

TKA: total knee arthroplasty

• TKA for valgus deformity of the knee (femorotibial angle by long leg X-ray < 170°)
• Simultaneous bilateral TKA
• Patients who had surgery in the ipsilateral knee or hip (e.g., total hip arthroplasty, high tibial osteotomy, fracture surgery, and hip osteotomy)
• Patients with severe bony defect requiring bone graft or augmentation
• Revision TKA
• TKA using other prostheses (i.e., not Vanguard Posterior-Stabilized)
• TKA not due to osteoarthritis or osteonecrosis (e.g., rheumatoid arthritis, trauma, and tumour)
• Patients with active knee joint infection
• Patients who had postoperative rehabilitation with different protocols

Table 2

Results of Spearman's rank correlation coefficient between the preoperative data and the knee flexion angle at three months after total knee arthroplasty

SD: standard deviation

	Mean ± SD (range)	**Correlation coefficient**	***p*-value (*: < 0.05)**
Postoperative knee flexion angle	121.2 ± 7.2 ° (95 - 130)	-	-
Preoperative values			
Knee flexion	124.8 ± 11.1 ° (90 - 140)	.797	.001*
Knee extension	-7.6 ± 4.4 ° (-15 - 0)	.223	.0332
Hip flexion	124.8 ± 11.1 ° (100 - 135)	.616	.007*
Hip extension	7.6 ± 5.8 ° (-5 - 20)	- .226	.325
Hip abduction	33.3 ± 6.4 ° (25 - 50)	- .009	.337
Hip adduction	8.8 ± 5.2 ° (0 - 20)	- .192	.403
Hip external rotation	24.3 ± 9.1 °	.576	.012*

	(5 - 45)		
Hip internal rotation	27.4 ± 11.7 °	.128	.582
	(5 - 45)		
Age	74.4 ± 6.7 years	- .034	.780
	(62 - 83)		
Body Mass Index	26.7 ± 2.8 kg/m^2	.003	.989
	(22.3 - 32.8)		
Serum albumin	4.0 ± 0.3 g/dl	.098	.672
	(3.5 - 4.7)		
HbA1c	5.7 ± 0.4 %	.342	.130
	(5.1 - 6.6)		
Kellgren-Lawrence grade	III: 1, IV: 20	.038	.871
Knee extension strength	14.3 ± 30.3 N/kg	.295	.194
Femorotibial angle	178.5 ± 5.0 °	- .185	.423
	(170 - 186)		