―**Original**―

Effect of Medial Osteophyte Removal on Correction of Varus Deformity in Total Knee Arthroplasty

Norishige Iizawa, Yasushi Oshima, Tatsunori Kataoka, Tokifumi Majima and Shinro Takai

Department of Orthopaedic Surgery, Nippon Medical School, Tokyo, Japan

Background: To restore neutral limb alignment in total knee arthroplasty (TKA), the procedure usually starts with removing osteophytes in varus osteoarthritic knees. However, the exact effect on alignment correction is unknown. The purpose of this study was to determine the effect of osteophyte removal alone during TKA for varus knees on correction of limb alignment on the coronal plane.

Methods: Fifteen knees with medial osteoarthritis and varus malalignment scheduled for TKA were studied. After registration in a navigation system, each knee was tested at maximum extension, and at 30, 40, and 60 degrees of flexion, before and after osteophyte removal. External loads of 10 N・m valgus torque at each angle and in both states were applied. Later, the widths of the resected osteophytes were measured.

Results: The average preoperative hip-knee-ankle angle was -14.2 degrees. The average width of osteophytes was 7.6 mm in the femur and 5.3 mm in the tibia. Angle corrections after osteophyte removal were 3.4 degrees at maximum extension, 3.4 degrees at 30 degrees flexion, and 3.6 degrees at 60 degrees flexion; the difference was significant for all angles. There was a positive correlation between osteophyte width and the degree of angle correction at 30 degrees.

Conclusion: At 30 degrees of knee flexion, osteophyte width was correlated with the degree of angle correction on the coronal plane in TKA. The degree of angle correction per 1 mm of width of removed osteophytes was 0.4 degrees. (J Nippon Med Sch 2020; 87: 215–219)

Key words: total knee arthroplasty (TKA), osteophyte, correction of varus deformity, angle correction

Introduction

In the medial osteoarthritic knee, varus deformity is a common angular deformity, and total knee arthroplasty (TKA) is effective in removing pain, improving physical function, and providing high satisfaction for patients with advanced knee osteoarthritis[1,2]. To correct varus deformity, osteophytes are usually removed after release of the deep medial collateral ligament (dMCL)[3,4], followed by release of the superficial medial collateral ligament (sMCL) and posteromedial capsule, including the posterior oblique ligament (POL)[5]. However, release of the dMCL and POL increases rotatory instability of the knee[6] and posterior translation of the medial condyle of femur with flexion in cruciate-retaining TKA (CR-TKA)[7]. After TKA, medial pivot motion was associated with good clinical outcomes[8]. To obtain normal knee kinematics, medial structures should be preserved to the greatest extent possible[6]. However, the precise effects of osteophyte removal without medial release on deformity correction are unknown. The ability to predict how much correction can be achieved by osteophyte removal alone, before performing ligament release, would help avoid unnecessary ligament release. Using intraoperative measurements, we examined the effect of osteophyte removal alone on correction of varus deformed knees.

Materials and Methods

Sixty-eight patients underwent primary TKA, performed

Correspondence to Norishige Iizawa, MD PhD, Department of Orthopaedic Surgery, Nippon Medical School, 1–1–5 Sendagi, Bunkyo-ku, Tokyo 113–8602, Japan
E-mail: n.iizawa@nms.ac.jp
https://doi.org/10.1272/jnms.JNMS.2020_87-503
Journal Website (https://www.nms.ac.jp/sh/jnms/)

Table 1 Demographic characteristics of patients

Age, y, mean ± SD (range)	77.3 ± 6.54 (64-86)
Gender (male/female)	2 (2 knees)/11 (13 knees)
Side (right/left)	8/7
Preoperative FTA, degrees, mean ±SD (range)	186.9 ± 6.61 (180.1 – 203.4)
Preoperative HKA angle, degrees, mean ±SD (range)	-14.2 ± 6.10 (-6.7 – -25.7)
K-L scale (knees)	Grade 2: 3
	Grade 3: 5
	Grade 4: 7

FTA: lateral femorotibial angle, HKA: hip-knee-ankle, K-L: Kellgren-Lawrence

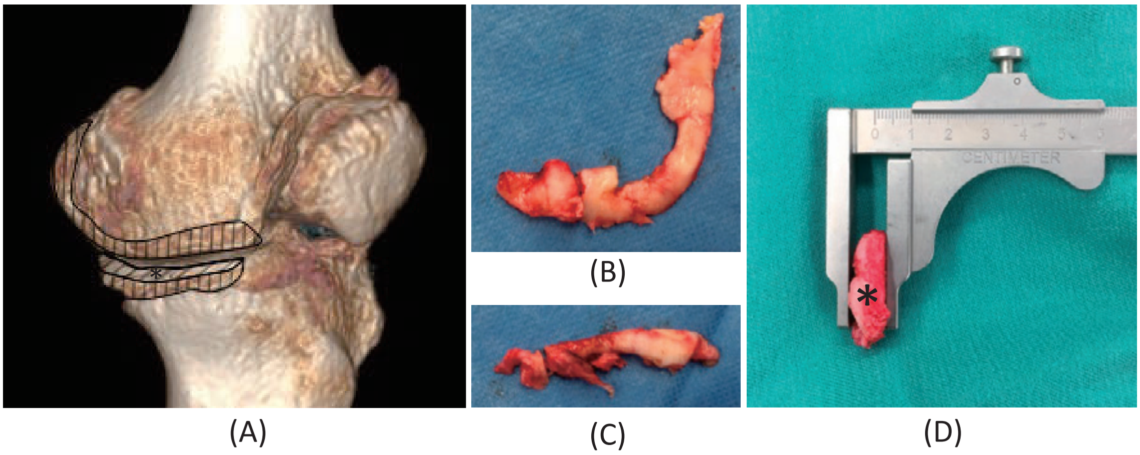

Fig. 1 (A) 3D image of knee joint (▥ : area of osteophyte removal, ＊: width of removed osteophyte). (B) Removed osteophytes on femoral and (C) tibial sides. (D) Maximum osteophyte width (＊) on femoral and tibial sides was measured with a vernier caliper.

by the same surgeon, during the period from January 2015 through October 2017. After excluding patients who underwent simultaneous bilateral surgery or surgery with augmentation and those with diabetes, 15 knees with medial osteoarthritis (OA) were included in the analysis. Mean patient age was 77.3 (64-86) years, and 2 knees of 2 men and 13 knees of 11 women (8 right and 7 left knees) were studied. Mean preoperative lateral femorotibial angle (FTA) was 188.7°±6.67° and hip-knee-ankle (HKA) angle was -14.2°±6.10°. On the Kellgren-Lawrence classification, 3 knees were Grade 2, 5 knees were Grade 3, and 7 knees were Grade 4 (**Table 1**).

Surgery was performed by using a medial parapatellar approach, and a navigation system (Knee 2.6.0: BrainLab, Germany) was set and registered. Without soft-tissue release or removal of meniscus, the first measurement was performed before removing osteophytes. Measurements were taken at maximal extension, and at 30°, 40°, and 60° of knee flexion, without a load (Step 1) and with a 10 N・m valgus load (Step 2) applied with a Ligament Tensioner (Meira Corp., Japan). The parameters measured with the navigation system were maximal extension angle and the angle created by the thigh axis and lower leg axis on the navigation system (HKA angle). Next, osteophytes on the femoral and tibial sides were removed to the extent possible (**Fig. 1**), while protecting the deep medial collateral ligament (dMCL). A 10 N・m valgus load was applied at the same angles (Step 3), to measure the parameters (**Table 2**). Maximum osteophyte width on the femoral and tibial sides was measured with a vernier caliper.

Table 2 Conditions at each step

	Osteophyte	Valgus force (10 Nm)
Step 1	+	-
Step 2	+	+
Step 3	-	+

Maximum extension angle before and after osteophyte removal and HKA at each step were recorded. By using these data, HKA difference before and after osteophyte removal (corrected angle) and the association between maximum osteophyte width and corrected angle were evaluated. Furthermore, the amount of correction achieved by removing 1 mm of osteophyte was calculated (ie, mean corrected angle/mean osteophyte width). The paired t-test and Pearson correlation coefficients were used in statistical analysis with Excel Toukei (Tokyo, Japan). A P value of <0.05 was considered statistically significant. This study was approved by the institutional review board of Nippon Medical School (R1-05-1122).

Results

Mean osteophyte width was 7.6±2.38 mm on the femoral side and 5.3±2.86 mm on the tibial side (**Table 3**). Only 2 patients had osteophyte widths that were greater on the tibial side than on the femoral side. Maximum osteophyte width, on the femoral or tibial side, was 7.8±2.51 mm. There was no difference in maximum extension angle, regardless of load or osteophyte removal (**Table 4**). HKA at maximum extension angle was -10.6°±6.56° at Step 1 but was -7.7°±6.56° (a significant difference) with a 10 N・m valgus load and -4.3°±5.49° at Step 3. The values at 30° of knee flexion at Steps 1 through 3 were -8.2°±6.81°, -4.1°±5.31°, and -0.8°±3.92°, respectively; at 60° flexion, the respective values were -7.2°±6.77°, -4.1°±6.11°, and -0.4°±4.67°. All differences were significant (**Table 5**). Mean HKA difference after osteophyte removal with a valgus load (corrected angle) was 3.4°±3.19°, 3.4±2.17°, and 3.6±3.27° at maximum extension, 30°, and 60° flexion, respectively (**Table 6**). The correlation between osteophyte width and corrected angle by osteophyte removal was highest at 30° flexion (r=0.727) (**Fig. 2**). At 30° flexion, the correlation was strong, and the mean correction was 3.4°; thus, 0.4° correction was achieved per 1 mm of osteophyte width.

Table 3 Width of resected osteophytes (mm, mean ±SD (range))

Femoral	7.6 ± 2.38 (3.0-11.0)
Tibial	5.3 ± 2.86 (2.1-10.0)
Larger side (femur or tibia)	7.8 ± 2.51 (3.0-11.0)

Discussion

Mean osteophyte removal of 7.8 mm with a valgus load corrected HKA by a mean of 3.4° at maximal extension and a mean of 3.4° at 30° of knee flexion. A simple valgus load, without osteophyte removal, achieved a mean of 3.0° at maximal extension and 4.0° of HKA correction at 30° of knee flexion. Thus, combining osteophyte removal with a valgus load corrected HKA by a mean of 6.3° at an extended position and 7.4° at 30° of knee flex-

Table 4 Maximum extension angles

	Step 1	Step 2	Step 3
Maximum extension angle, mean ±SD, (range)	9.0 ± 6.60 (-0.5 – 22.5)	8.3 ± 7.20 (-4.5 – 21.3)	6.8 ± 6.54 (-5.5 – 21.7)

There were no significant differences between groups.
p-value: Group A vs. B = 0.31, Group A vs. C = 0.07, Group B vs. C = 0.18

Table 5 HKA (degrees) in relation to knee flexion angle and step.

	Step 1	Step 2	Step 3
Maximum extension, mean ±SD, (range)	-10.6 ± 6.56 (-20.0 – -1.5)	-7.7 ± 6.56 (-20.5 – 0.7) *	-4.3 ± 5.49 (-15.2 ~1.3) *
30˚	-8.2 ± 6.81 (-20.0 – 1.0)	-4.1 ± 5.31 (-16.0 – 2.5) *	-0.8 ± 3.92 (-7.5 ~ 4.7) *
40˚	-8.9 ± 7.27 (-20.0 – -0.5)	-5.3 ± 6.62 (-16.0 – 3.8) *	-1.0 ± 4.58 (-7.8 ~ 5.2) *
60˚	-7.2 ± 6.77 (-14.0 – 3.0)	-4.1 ± 6.11 (-14.0 – 5.5) *	-0.4 ± 4.67 (-8.5 ~ 7.0) *

* significant difference vs. previous group at same angle

Table 6 Differences between steps

	Step 1 to 2	Step 2 to 3	Total (Step 1 to 3)
Maximum extension, mean ±SD, (range)	3.0 ± 1.68 (0 – 6.5)	3.4 ± 3.19 (0.7 – 11.5)	6.3 ± 3.02 (2.8 – 14.8)
30°	4.0 ± 2.63 (1.5 – 12.0)	3.4 ± 2.17 (0.5 – 8.5)	7.4 ± 3.84 (3.5 – 17.7)
40°	3.5 ± 1.87 (1.5 – 8.0)	4.3 ± 3.13 (1.0 – 11.0)	7.9 ± 3.41 (4.5 – 13.5)
60°	3.1 ± 1.48 (1.0– 6.3)	3.6 ± 3.27 (0.3 – 12.2)	6.8 ± 4.02 (3.5 – 18.5)

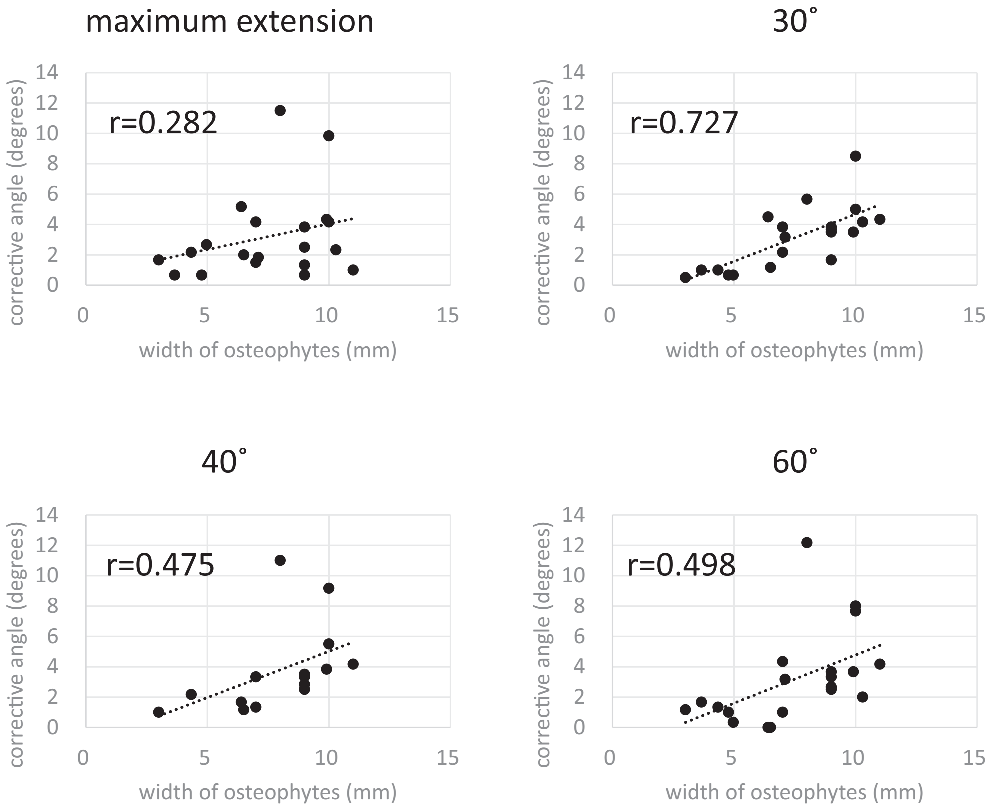

Fig. 2 Correlation between corrective angle and osteophyte width

ion. Bellmans et al.[9] reported that suitable correction was possible with osteophyte removal alone in patients with less than 185° of FTA. Ushio et al.[10] and Okamoto et al.[11] reported that medial structures, including the MCL, are not shortened in knees with varus deformity. Thus, present and past results indicate that osteophyte removal alone can achieve some degree of correction, at least in knees with an FTA less than 185°.

Corrected angle was correlated with osteophyte size at 30° of knee flexion in this study, which equated to 0.4° of correction per 1 mm of osteophyte width. Mullaji et al.[12] reported that 2-mm reduction osteotomy is required to achieve 1° of correction, which is equal to 0.5° for each 1 mm of bone resected. However, this angle may actually represent a larger angle than the corrected angle in the present study because the dMCL was consistently released as well.

Whiteside et al.[13] reported that ligament imbalance correction by osteophyte removal alone improved extension in many patients. Injury to the posterolateral side or cruciate ligament was reported to be a potential cause of hyperextension[14]. There was no significant pre/post difference in maximal extension angle after osteophyte removal in the present study, because only medial osteophyte removal was performed; osteophytes at the posterior condyles or intercondylar notch were not removed and the cruciate ligament was not altered.

Some similar studies applied a manual maximum valgus load[9,15]. In this study, a 10 N・m load was applied, as in other studies of ligaments in normal knees[16] and TKA knees[6]. Applying a 10 N・m valgus load at 30° flexion in normal knees, Griffith et al.[16] reported a 6.5° correction. The present knees were all OA knees; thus, a direct comparison is not possible. However, the present study found a 3.7° correction by applying a 10 N・m valgus load at 30° flexion. This result was obtained when osteophytes that increased tension to medial structures were present.

This study has several limitations. First, the sample size was small. It was not possible to investigate whether the corrected angle obtained by osteophyte removal was affected by the severity of varus deformity. Next, only osteophytes on the medial side were removed completely. Because the measurements were made only by applying a valgus load, the effect on the results was likely insignificant, but it may have affected the results for patients with insufficient correction after osteophyte removal. Third, only the relationship between osteophyte width and correction angle was analyzed. Future studies should examine the relationship between osteophyte length and volume. The last limitation is that the effect of osteophyte removal, without medial release, on knee kinematics was not measured. These issues will be addressed in a future study.

Conclusion

A valgus load combined with osteophyte removal achieved some HKA correction of varus deformity. A correction of 0.4° was achieved for each 1 mm of osteophyte removed, as assessed on the coronal plane, in TKA knees without soft tissue release.

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

References

1. Kahlenberg CA, Nwachukwu BU, McLawhorn AS, Cross MB, Cornell CN, Padgett DE. Patient satisfaction after total knee replacement: A systematic review. HSS J. 2018;14: 192–201.
2. Nakahara H, Okazaki K, Mizu-Uchi H, et al. Correlations between patient satisfaction and ability to perform daily activities after total knee arthroplasty: Why aren't patients satisfied? J Orthop Sci. 2015;20:87–92.
3. Kim MW, Koh IJ, Kim JH, Jung JJ, In Y. Efficacy and safety of a novel three-step medial release thchnique in varus total knee arthroplasty. J Arthroplasty. 2015;30: 1542–7.
4. Verdonk PC, Pernin J, Pinaroli A, Ait Si, Selmi T, Neyret P. Soft tissue balancing in varus total knee arthroplasty: an algorithmic approach. Knee Surg Sports Traumatol Arthrosc. 2009;17:660–6.
5. Clayton ML, Thompson TR, Mack RP. Correction of alignment deformities during total knee arthroplasties: staged soft-tissue releases. Clin Orthop Relat Res. 1986;202:117–24.
6. Iizawa N, Mori A, Majima T, Kawaji H, Matsui S, Takai S. Influence of the medial knee structures on valgus and rotatory stability in total knee arthroplasty. J Arthroplasty. 2016;31:688–93.
7. Iizawa N, Mori A, Oshima Y, Matsui S, Kataoka T, Takai S. Influence of the individual components of the main medial knee structures on medial pivot in total knee arthroplasty. Orthopaedic Proceedings. 2016;98-B(sup 8):47.
8. Nishio Y, Onodera T, Kasahara Y, Takahashi D, Iwasaki N, Majima T. Intraoperative medial pivot affects deep knee flexion angle and patient-reported outcomes after total knee arthroplasty. J Arthroplasty. 2014;29:702–6.
9. Bellemans J, Vandenneucker H, Vanlauwe J, Victor J. The influence of coronal plane deformity on mediolateral ligament status: an observational study in varus knees. Knee Surg Sports Traumatol Arthrosc. 2010;18:152–6.
10. Ushio T, Mizuuchi H, Okazaki K, et al. Medial soft tissue contracture does not always exist in varus osteoarthritis knees in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2019;27:1642–50.
11. Okamoto S, Okazaki K, Mitsuyasu H, Matsuda S, Iwamoto Y. Lateral soft tissue laxity increases but medial laxity does not contract with varus deformity in total knee arthroplasty. Clin Orthop Relat Res. 2013;471:1334–42.
12. Mullaji AB, Shetty GM. Correction of varus deformity during TKA with reduction osteotomy. Clin Orthop Relat Res. 2014;472:126–32.
13. Whiteside LA, Mihalko WM. Surgical procedure for flexion contracture and recurvatum in total knee arthroplasty. Clin Orthop Relat Res. 2002;404:189–95.
14. Fornalski S, McGarry MH, Csintalan RP, Fithian DC, Lee TQ. Biomechanical and anatomical assessment after knee hyperextension injury. Am J Sports Med. 2008;36:80–4.
15. Mehliß V, Strauch Leira M, Serrano Olaizola A, Scior W, Graichen H. Proven accuracy for a new dynamic gap measurement in navigated TKA. Knee Surg Sports Traumatol Arthrosc. 2019;27:1189–95.
16. Griffith CJ, LaPrade RF, Johansen S, Armitage B, Wijdicks C, Engebretsen L. Medial knee injury. Part 1, static function of the individual components of the main medial knee structures. Am J Sports Med. 2009;37:1762–70.

(Received, July 16, 2019)
(Accepted, December 25, 2019)
(J-STAGE Advance Publication, January 31, 2020)